GE Medical Systems

Technical Publications

Direction 46−013288

Revision 14

Bleeder, High−Voltage Dual Type T8005G and C1515A Connection . . . Applications

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Operating Documentation

WARNING

- **THIS SERVICE MANUAL IS AVAILABLE IN ENGLISH ONLY.**
- **IF A CUSTOMER'S SERVICE PROVIDER REQUIRES A LANGUAGE OTHER THAN ENGLISH, IT IS THE CUSTOMER'S RESPONSIBILITY TO PROVIDE TRANSLATION SERVICES.**
- **DO NOT ATTEMPT TO SERVICE THE EQUIPMENT UNLESS THIS SERVICE MANUAL HAS BEEN CONSULTED AND IS UNDERSTOOD.**
- **FAILURE TO HEED THIS WARNING MAY RESULT IN INJURY TO THE SERVICE PROVIDER, OPERATOR OR PATIENT FROM ELECTRIC SHOCK, MECHANICAL OR OTHER HAZARDS.**

AVERTISSEMENT

- **CE MANUEL DE MAINTENANCE N'EST DISPONIBLE QU'EN ANGLAIS.**
- **SI LE TECHNICIEN DU CLIENT A BESOIN DE CE MANUEL DANS UNE AUTRE LANGUE QUE L'ANGLAIS, C'EST AU CLIENT QU'IL INCOMBE DE LE FAIRE TRADUIRE.**
- **NE PAS TENTER D'INTERVENTION SUR LES ÉQUIPEMENTS TANT QUE LE MANUEL SERVICE N'A PAS ÉTÉ CONSULTÉ ET COMPRIS.**
- **LE NON-RESPECT DE CET AVERTISSEMENT PEUT ENTRAÎNER CHEZ LE TECHNICIEN, L'OPÉRATEUR OU LE PATIENT DES BLESSURES DUES À DES DANGERS ÉLECTRIQUES, MÉCANIQUES OU AUTRES.**

WARNUNG

- **DIESES KUNDENDIENST−HANDBUCH EXISTIERT NUR IN ENGLISCHER SPRACHE.**
- **FALLS EIN FREMDER KUNDENDIENST EINE ANDERE SPRACHE BENÖTIGT, IST ES AUFGABE DES KUNDEN FÜR EINE ENTSPRECHENDE ÜBERSETZUNG ZU SORGEN.**
- **VERSUCHEN SIE NICHT, DAS GERÄT ZU REPARIEREN, BEVOR DIESES KUNDENDIENST−HANDBUCH NICHT ZU RATE GEZOGEN UND VERSTANDEN WURDE.**
- **WIRD DIESE WARNUNG NICHT BEACHTET, SO KANN ES ZU VERLETZUNGEN DES KUNDENDIENSTTECHNIKERS, DES BEDIENERS ODER DES PATIENTEN DURCH ELEKTRISCHE SCHLÄGE, MECHANISCHE ODER SONSTIGE GEFAHREN KOMMEN.**

AVISO

- **ESTE MANUAL DE SERVICIO SÓLO EXISTE EN INGLÉS.**
- **SI ALGÚN PROVEEDOR DE SERVICIOS AJENO A GEMS SOLICITA UN IDIOMA QUE NO SEA EL INGLÉS, ES RESPONSABILIDAD DEL CLIENTE OFRECER UN SERVICIO DE TRADUCCIÓN.**
- **NO SE DEBERÁ DAR SERVICIO TÉCNICO AL EQUIPO, SIN HABER CONSULTADO Y COMPRENDIDO ESTE MANUAL DE SERVICIO.**
- **LA NO OBSERVANCIA DEL PRESENTE AVISO PUEDE DAR LUGAR A QUE EL PROVEEDOR DE SERVICIOS, EL OPERADOR O EL PACIENTE SUFRAN LESIONES PROVOCADAS POR CAUSAS ELÉCTRICAS, MECÁNICAS O DE OTRA NATURALEZA.**

ATENÇÃO

- **ESTE MANUAL DE ASSISTÊNCIA TÉCNICA SÓ SE ENCONTRA DISPONÍVEL EM INGLÊS.**
- **SE QUALQUER OUTRO SERVIÇO DE ASSISTÊNCIA TÉCNICA, QUE NÃO A GEMS, SOLICITAR ESTES MANUAIS NOUTRO IDIOMA, É DA RESPONSABILIDADE DO CLIENTE FORNECER OS SERVIÇOS DE TRADUÇÃO.**
- **NÃO TENTE REPARAR O EQUIPAMENTO SEM TER CONSULTADO E COMPREENDIDO ESTE MANUAL DE ASSISTÊNCIA TÉCNICA.**
- **O NÃO CUMPRIMENTO DESTE AVISO PODE POR EM PERIGO A SEGURANÇA DO TÉCNICO, OPERADOR OU PACIENTE DEVIDO A' CHOQUES ELÉTRICOS, MECÂNICOS OU OUTROS.**

AVVERTENZA

- **IL PRESENTE MANUALE DI MANUTENZIONE È DISPONIBILE SOLTANTO IN INGLESE.**
- **SE UN ADDETTO ALLA MANUTENZIONE ESTERNO ALLA GEMS RICHIEDE IL MANUALE IN UNA LINGUA DIVERSA, IL CLIENTE È TENUTO A PROVVEDERE DIRETTAMENTE ALLA TRADUZIONE.**
- **SI PROCEDA ALLA MANUTENZIONE DELL'APPARECCHIATURA SOLO DOPO AVER CONSULTATO IL PRESENTE MANUALE ED AVERNE COMPRESO IL CONTENUTO.**
- **NON TENERE CONTO DELLA PRESENTE AVVERTENZA POTREBBE FAR COMPIERE OPERAZIONI DA CUI DERIVINO LESIONI ALL'ADDETTO ALLA MANUTENZIONE, ALL'UTILIZZATORE ED AL PAZIENTE PER FOLGORAZIONE ELETTRICA, PER URTI MECCANICI OD ALTRI RISCHI.**

警告

・このサービスマニュアルには英語版しかありません。
・ＧＥＭＳ以外でサービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。
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・この警告に従わない場合、サービスを担当される方、操作員あるいは患者さんが、感電や機械的又はその他の危険により負傷する可能性があります。

注意:

- 本维修手册仅存有英文本。
- 非 GEMS 公司的维修员要求非英文本的维修手册时，客户需自行负责翻译。
- 未详细阅读和完全了解本手册之前，不得进行维修。
- 忽略本注意事项会对维修员，操作员或病人造成触电，机械伤害或其他伤害。

Direction 46–013288

Revision 14

Bleeder, High-Voltage Dual Type T8005G and C1515A Connection . . . Applications

IMPORTANT! . . . X-RAY PROTECTION

X-ray equipment if not properly used may cause injury. Accordingly, the instructions herein contained should be thoroughly read and understood by everyone who will use the equipment before you attempt to place this equipment in operation. The General Electric Company, Medical Systems Group, will be glad to assist and cooperate in placing this equipment in use.

Although this apparatus incorporates a high degree of protection against x-radiation other than the useful beam, no practical design of equipment can provide complete protection. Nor can any practical design compel the operator to take adequate precautions to prevent the possibility of any persons carelessly exposing themselves or others to radiation.

It is important that everyone having anything to do with x-radiation be properly trained and fully acquainted with the recommendations of the National Council on Radiation Protection and Measurements as published in NCRP Reports available from NCRP Publications, 7910 Woodmont Avenue, Room 1016, Bethesda, Maryland 20814, and of the International Commission on Radiation Protection, and take adequate steps to protect against injury.

The equipment is sold with the understanding that the General Electric Company, Medical Systems Group, its agents, and representatives have no responsibility for injury or damage which may result from improper use of the equipment.

Various protective material and devices are available. It is urged that such materials or devices be used.

CAUTION: United States Federal law restricts this device to use by or on the order of a physician.

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If you have any comments, suggestions or corrections to the information in this document, please write them down, include the document title and document number, and send them to:

GENERAL ELECTRIC COMPANY MEDICAL SYSTEMS
MANAGER – INFORMATION INTEGRATION,
AMERICAS W–622
P.O. BOX 414
MILWAUKEE, WI 53201–0414

CERTIFIED ELECTRICAL CONTRACTOR STATEMENT

All electrical installations that are preliminary to positioning of the equipment at the site prepared for the equipment shall be performed by licensed electrical contractors. In addition, electrical feeds into the Power Distribution Unit shall be performed by licensed electrical contractors. Other connections between pieces of electrical equipment, calibrations, and testing shall be performed by qualified GE Medical personnel. The products involved (and the accompanying electrical installations) are highly sophisticated, and special engineering competence is required. In performing all electrical work on these products, GE will use its own specially trained field engineers. All of GE's electrical work on these products will comply with the requirements of the applicable electrical codes.

The purchaser of GE equipment shall only utilize qualified personnel (i.e., GE's field engineers, personnel of third-party service companies with equivalent training, or licensed electricians) to perform electrical servicing on the equipment.

DAMAGE IN TRANSPORTATION

All packages should be closely examined at time of delivery. If damage is apparent, have notation "**damage in shipment**" written on **all** copies of the freight or express bill **before** delivery is accepted or "signed for" by a General Electric representative or a hospital receiving agent. Whether noted or concealed, damage **MUST** be reported to the carrier **immediately** upon discovery, or in any event, within **14** days after receipt, and the contents and containers held for inspection by the carrier. A transportation company will not pay a claim for damage if an inspection is not requested within this **14** day period.

Call Traffic and Transportation, Milwaukee, WI (414) 827–3449 / 8*285–3449 **immediately** after damage is found. At this time be ready to supply name of carrier, delivery date, consignee name, freight or express bill number, item damaged and extent of damage.

Complete instructions regarding claim procedure are found in Section "S" of the Policy & Procedure Bulletins.

6/17/94

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SAFETY NOTE

When used as described, the HV Bleeder permits the oscilloscope case to be at ground potential, and no special precautions need be taken. Use of an ungrounded scope is never required, and such use for convenience is discouraged due to the safety hazard it creates. Form 3549 (Warning Sign) must be used if the oscilloscope case is floated above ground.

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REVISION HISTORY

REV	DATE	REASON FOR CHANGE
G	Mar. 5, 1982	This was the last of seven revisions (A through G) using the old revision control system
8	Nov. 20, 1986	Corrected calibrations with MPX in Table 2; General revisions.
9	Sept. 25, 1987	Add Section 4−7 for connecting HV Bleeder to AMX. Add MVP Micro to Table 1. Add LFX and MVP to Table 2.
10	Sept. 29, 1989	Make corrections to Table 2 on page 17 for primary volts for MPX/SPX80, 100; LFX; and MVP generators.
11	Apr. 2, 1993	Make corrections to Table 2 on page 17 for LFX and MVP 60, 80, 100.
12	Apr. 4, 1994	Add reference to 46−219921G1 − 30 ft. cable in Section 3. Add reference to 46−219921G2 − 17.5 ft. cable in Section 3 & Section 4−7.
13	Oct. 28, 1994	Correct Table 2 on page 17 for LFX and MVP 60, 80, 100.
14	Mar. 30, 1999	Updated page 11 (deleted references to CDX).

LIST OF EFFECTIVE PAGES

PAGE NUMBER	REVISION NUMBER	PAGE NUMBER	REVISION NUMBER	PAGE NUMBER	REVISION NUMBER
Title Page	14	13	8		
		14	Blank		
i thru x	14	15	9		
		16	8		
1	3−582	17	13		
2	Blank				
3	3−582	18	Blank		
4	Blank	19 thru 25	3−582		
5	12	26	Blank		
		27 thru 33	3−582		
6	Blank	34	Blank		
7 thru 9	9				
10	3−582	35	9		
11	14	36	Blank		
12	12	37 thru 43	3−582		
		44	Blank		
		45 thru 48	3−582		

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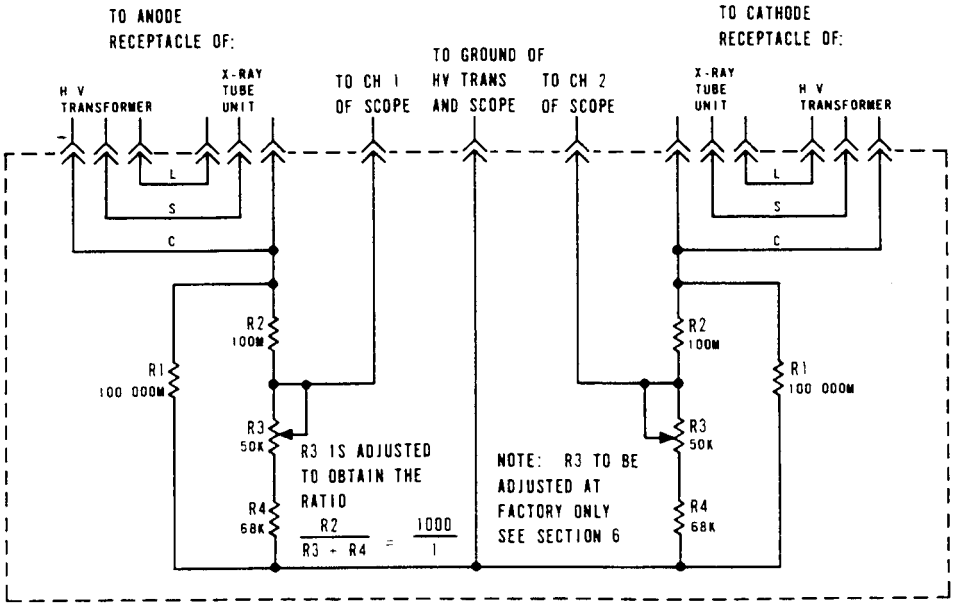
SECTION 1 - APPLICATION OF BLEEDER

When servicing X-ray generators, it is often desirable to know whether the kVp (kilovolts peak) from anode to ground is equal to that from cathode to ground and whether the peak instantaneous sum of the two voltages equals the value of kVp selected with the push button or dial on the X-ray control. It is also desirable to analyze waveforms to determine whether a HV transformer and X-ray tube are functioning normally at a particular kVp.

A test instrument that makes this possible is the HV Bleeder which is in effect a “very high voltage probe” for an oscilloscope.


TO ANODE RECEPTACLE OF:
H V TRANSFORMER
X-RAY TUBE UNIT
TO CH 1 OF SCOPE
TO GROUND OF HV TRANS AND SCOPE
TO CH 2 OF SCOPE
TO CATHODE RECEPTACLE OF:
X-RAY TUBE UNIT
H V TRANSFORMER
L
S
C
R1 100 000M
R2 100M
R3 50K
R4 68K
R3 IS ADJUSTED TO OBTAIN THE RATIO
R2 / R3 + R4 = 1000 / 1
NOTE: R3 TO BE ADJUSTED AT FACTORY ONLY SEE SECTION 6

HIGH-VOLTAGE BLEEDER T8005G

ILLUSTRATION 1

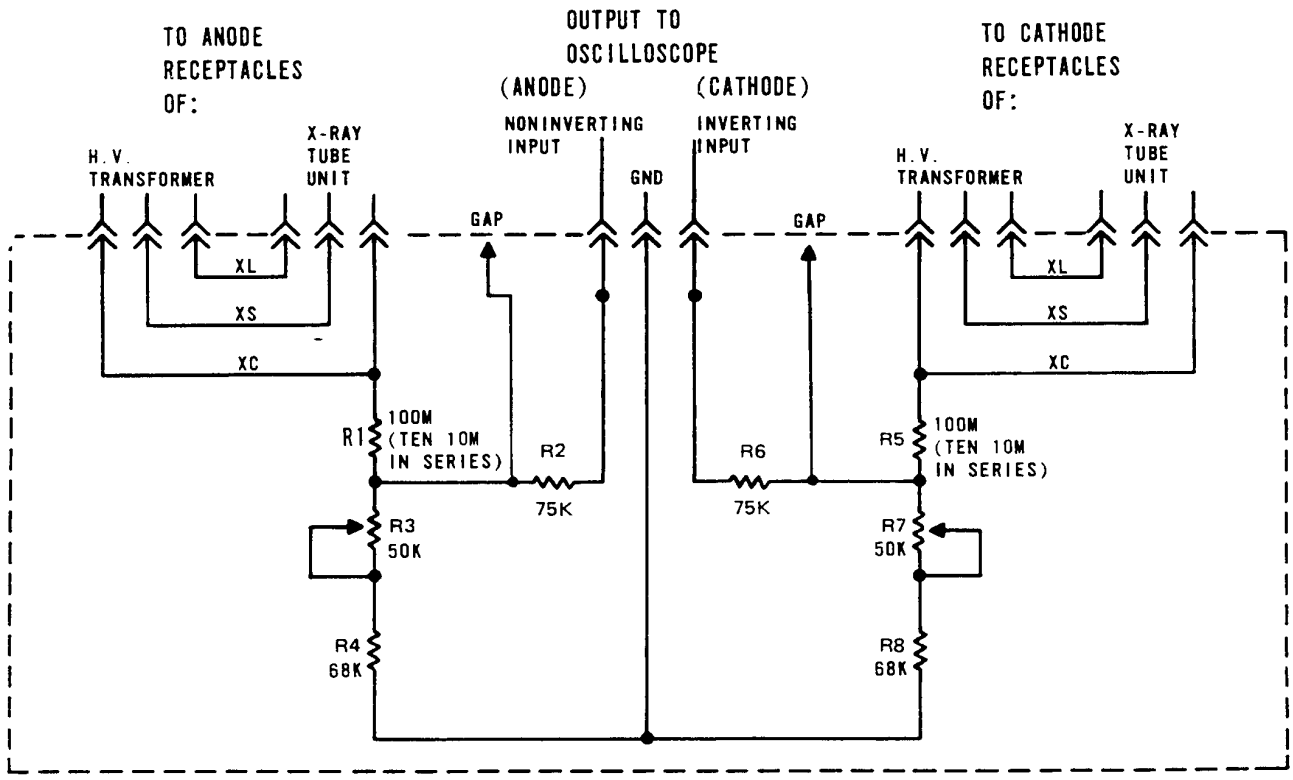
18731-D10

SECTION 2- DESCRIPTION AND FUNCTION

The HV Bleeder consists of two voltage dividers calibrated so that the output voltage of each is 1/1000 of the input voltage. These are encased in a 5-gallon drum filled with Diala AX insulating oil for insulation between components and protecting the operator from the high voltages. The dividers are tapped off the HV cables of the X-ray unit by two connected HV receptacles through the drum cover. These are used as a tie point for the HV cables on the X-ray unit and 5-ft. jumper cables from the Bleeder to the HV transformer or X-ray tube unit.

Illustration 1 shows the construction and use of the T8005G Bleeder, while Illustration 2 shows the C1515A Bleeder.

The two rheostats are factory adjusted so that the voltage taken off at the anode or cathode Bleeder, low voltage terminals will be 1/1000 of the high voltage from the anode or cathode receptacle to ground. Because the anode and cathode voltage peaks may not be exactly in phase, a dual trace scope with the algebraic addition feature must be used to add the anode and cathode voltages and give 1/1000 of the true peak kilovoltage for every instant during an exposure. An example of this is shown in Illustrations 32 and 33.



$$\frac{\text{OUTPUT}}{\text{INPUT}} = \frac{1}{1000}$$

NOTES:
1. R3 AND R7 TO BE ADJUSTED AT FACTORY ONLY. SEE SECTION 6.
2. STEEL BAND SEALS TOP COVER TO CAN AND ALSO CONNECTS THEM ELECTRICALLY.
3. SAFETY GAP IS .004" - .008"

HIGH-VOLTAGE BLEEDER C1515A

ILLUSTRATION 2

SECTION 3 – TOOLS AND MATERIALS

To use the Dual Type HV Bleeder for radiographic calibration or troubleshooting, the following items will be required:

1. One T8005G or one C1515A dual HV Bleeder.

2. Two 5 ft. (1.5 m) HV cables with standard termination at each end.

3. One dual trace oscilloscope capable of algebraic addition. Tektronix Model 468 or 465 Model UC are preferred. Model 434 is acceptable. Non-storage types are not recommended, but may be used with a scope camera.

4. One 30 ft. (9.1 m) twisted pair cable, low capacitance, 2–conductor, shielded, Belden No. 8422 (18 mmfd/ft), 46–219921G1, or equivalent. This permits locating the scope away from the area of radiation for safe viewing.

   A shorter 17.5 ft. (5.3 m) cable, 46–219921G2, improves the high frequency response of the HV Bleeder. The 17.5 ft. (5.3 m) cable must be used to obtain proper calibration on AMX X–ray units.

   Never use the bleeder without the specified cable as it is part of the calibration!

5. One homemade external scope trigger circuit as shown in Illustration 6. Use of this device permits viewing the zero volts line and all of the start portion of the waveform to be viewed. This is important in measuring kVp. For other purposes internal scope triggering may be used. This device is not needed with the 468 or 465 scopes.

6. For the T8005G Bleeder, eleven gallons of Diala AX transformer insulating oil are required. This Bleeder is shipped from the factory less oil and may have been emptied for shipment to points within the District or Zone. The C1515A Bleeder is shipped filled with oil.

7. A true RMS reading voltmeter must be used to set up the HV transformer primary voltage that is required to produce the kVp specified for the no–load or light load turns ratio test. It is also useful to obtain a record of HV transformer voltages which will be helpful if service is required at a later date. Meters acceptable for this are those that specifically state true RMS reading, such as: Fluke 8030A, Beckman 3030, Data Precision 245 or 255. Meters that are average responding but calibrated to read out in RMS are not acceptable. If in doubt, consult your operator's manual. Meters which rectify the AC and apply it to a DC meter movement, such as Simpson 260 or Triplett, are not acceptable because readings are affected by the shape of the AC waveform. Fluke models 8000/8000A, 8020 and 8024 are not acceptable.

8. A supply of silicone compound 46–125224P3 (from NPS) and Diala X transformer oil for use in HV cable receptacles. This material must be clean and free of contamination.

SECTION 4 — PROCEDURE FOR INTERCONNECTION

The accuracy of results with a HV Bleeder depends upon accurate calibration of the Bleeder and the oscilloscope and the careful, precise readings by the service representative. For best results follow these instructions carefully.

4-1 FILL T8005G BLEEDER WITH OIL

1. There is a circular bakelite disc insulator at the bottom of the Bleeder drum. It must be removed or held in a vertical position while oil is poured into the Bleeder. Otherwise a large bubble of air is trapped under the disc and some of it may escape later during use resulting in arcing within the Bleeder.

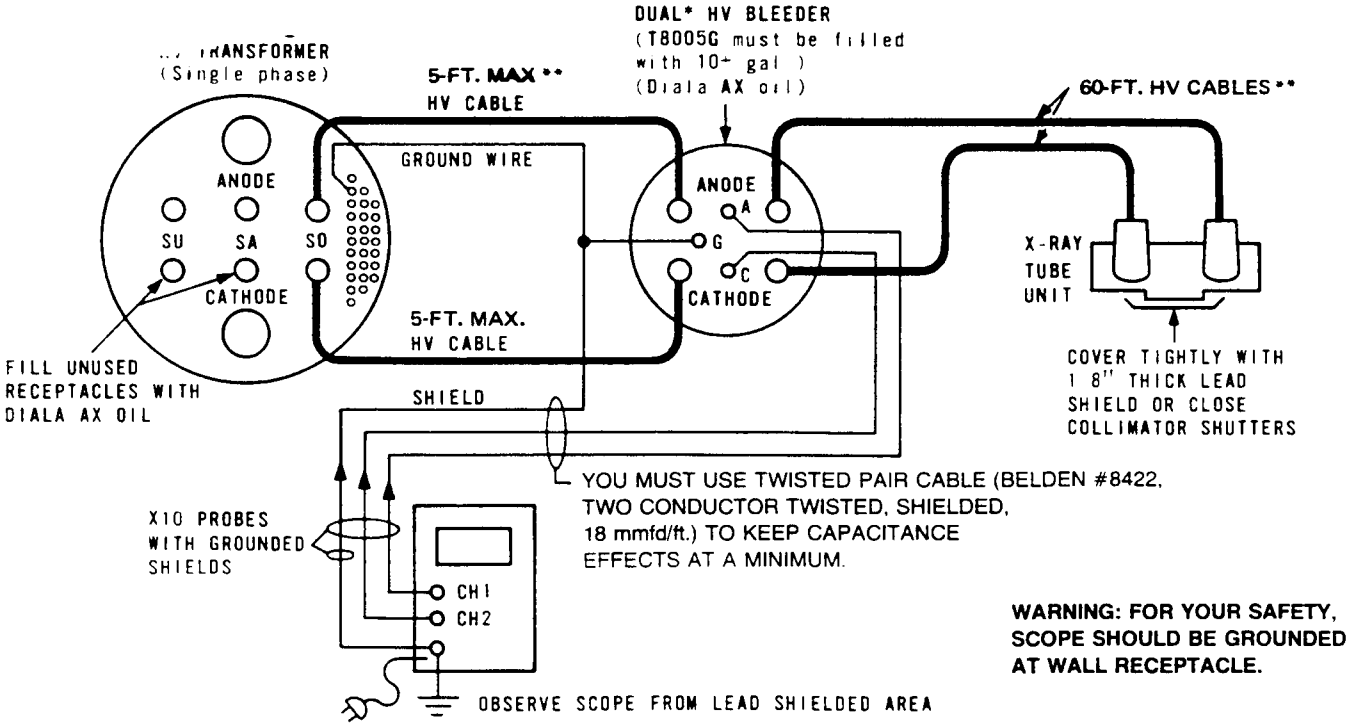
2. Fill the can with Diala AX oil to within 1" of the top. Place the resistor and cover assembly in position and install the clamp ring. Insufficient oil will result in arcing at the tops of the receptacles.

4-2 CHECK C1515A BLEEDER OIL LEVEL

Remove oil filler plug and check oil level. Oil level shall be up to base of filler plug. Add Diala AX oil as needed to make up oil losses from leakage. Replace filler cap and secure vent screw as soon as possible so that oil has minimum exposure to atmosphere. (Oil absorbs atmospheric water vapor.)

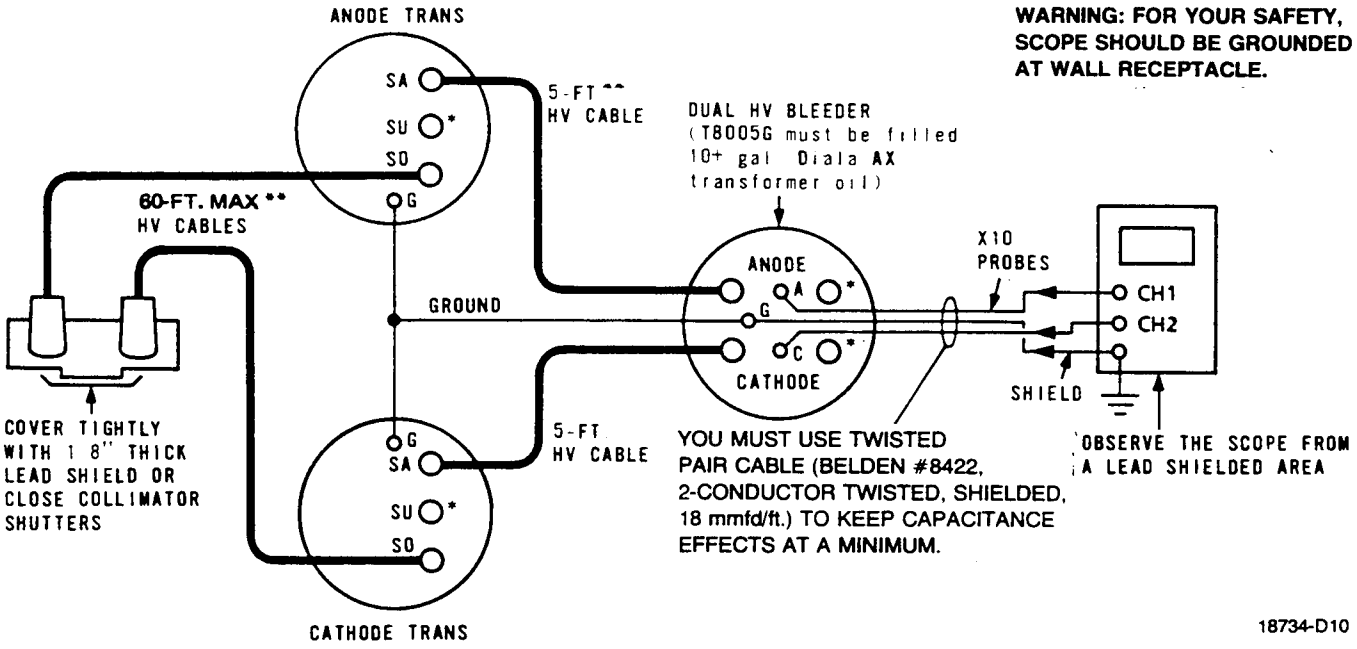
4-3 CONNECT THE HV CABLES

Remove anode and cathode HV cables from the X-ray tube unit (or HV transformer) and insert them into an anode and a cathode receptacle of the Bleeder. Insert one end of one 5 ft. jumper HV cable into the Bleeder anode receptacle and the other end into the X-ray tube unit (or HV transformer) anode receptacle. Install the other 5 ft. HV cable similarly, but in the cathode receptacles. The connections now should correspond with Illustrations 3, 4, 5, 6 or 7. Follow the procedure given on Page 11 to expel all air out of the HV cable terminal to receptacle junctions. FAILURE TO DO THIS PROPERLY CAN RESULT IN ARCING AT THE JUNCTIONS AND HV TRANSIENTS THAT DAMAGE THE X-RAY APPARATUS.



CONNECTION OF HV BLEEDER TO A SINGLE-PHASE X-RAY UNIT

ILLUSTRATION 3

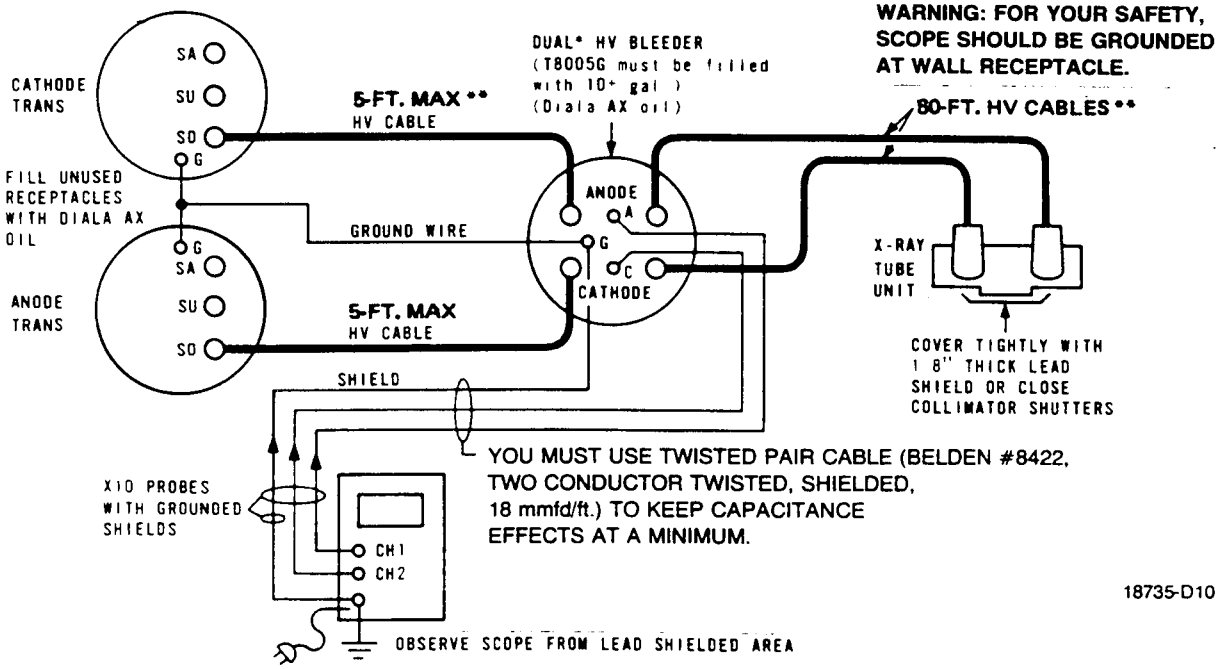


* FILL UNUSED RECEPTACLES WITH OIL

** RELATIVE POSITIONS OF 5 FT. AND 60 FT. CABLES IN DRAWING MAY BE INTERCHANGED

CONNECTION OF HV BLEEDER TO A THREE-PHASE -RAY UNIT (TWO-TRANSFORMER TYPE) WITHOUT AN SA X-RAY TUBE

ILLUSTRATION 4

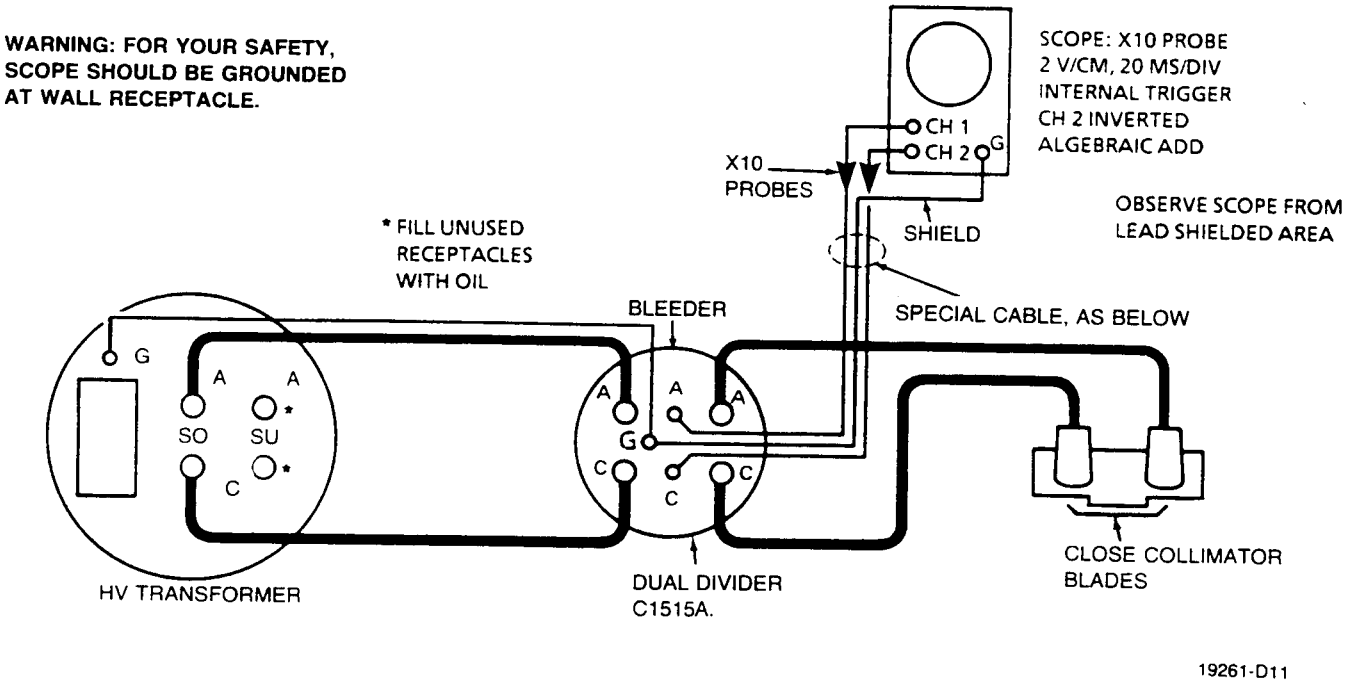


* TWO SINGLE HV BLEEDERS MAY BE USED

** RELATIVE POSITIONS OF 5 FT. AND 60 FT. CABLES IN DRAWING MAY BE INTERCHANGED

CONNECTION OF HV BLEEDER TO A THREE-PHASE -RAY UNIT (TWO-TRANSFORMER TYPE) WITH AN SA X-RAY TUBE

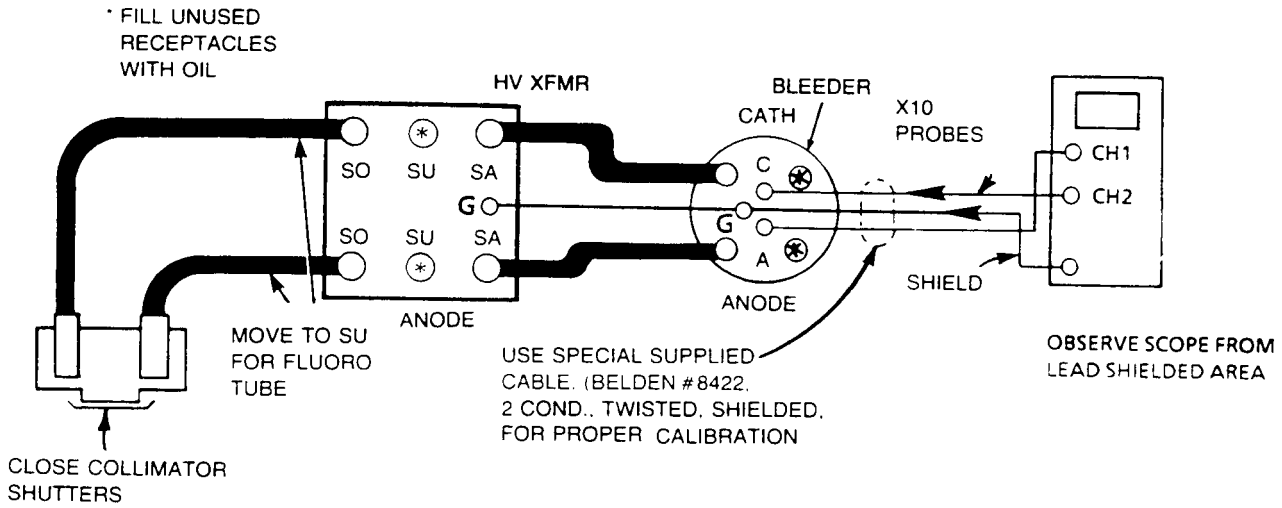
ILLUSTRATION 5



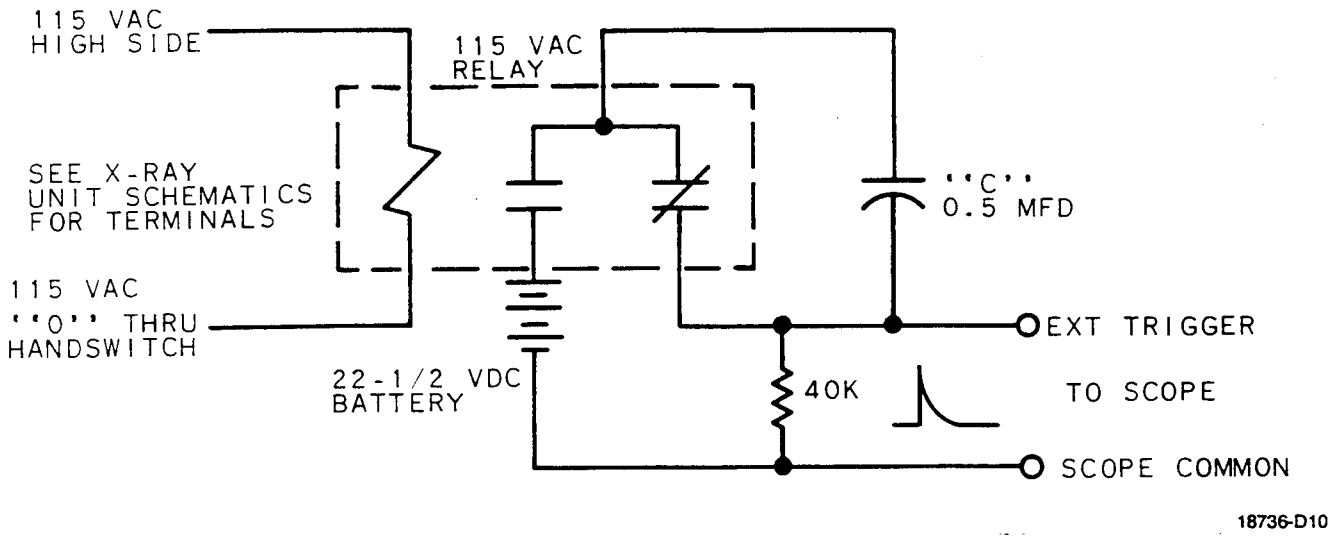
CONNECTION OF HV BLEEDER TO 2-TUBE TRANSFORMER
ILLUSTRATION 6

CAUTION: IF THE SYSTEM INCLUDES AN SA TUBE, DO NOT ATTEMPT TO JUMPER SA FUNCTIONS TO SO OR TO SU FUNCTIONS AS ROTOR CONTROLLER DAMAGE MAY RESULT. USE ILLUSTRATION 6 INSTEAD.

WARNING: FOR YOUR SAFETY, SCOPE SHOULD BE GROUNDED AT WALL RECEPTACLE.



CONNECTION OF HV BLEEDER TO 3-TUBE TRANSFORMER
ILLUSTRATION 7



TYPICAL EXTERNAL TRIGGER FOR SCOPE
ILLUSTRATION 8

NOTE: SWEEP DELAY MAY BE INCREASED BY INCREASING THE VALUE OF "C", AND VICE VERSA.

THIS DEVICE PERMITS VIEWING THE ZERO VOLTS LINE AND ALL OF THE START PORTION OF THE WAVEFORM, AND IS IMPORTANT IN MEASURING KVP. FOR OTHER PURPOSES, INTERNAL SCOPE TRIGGERING IS USUALLY ADEQUATE.

Procedure for Making High–Voltage Connections

1. Use Diala AX transformer oil in transformer receptacles or any others that will be used in an upright position. Use Silicone compound 46–125224P3 in X–ray tube unit receptacles or any others which will be used in various positions and from which oil would leak out. Procure from National Parts Service.

2. Inspect the receptacle. If necessary, use a small amount of transformer oil to clean out dirt and moisture. Dry thoroughly with a clean, lint–free cloth or paper.

3. Clean the HV cable terminal with a small amount of transformer oil. Dry it thoroughly with a clean, lint–free cloth or paper. Inspect for correct spread of the pin ends. Remove excess solder, if any, on the pins that would prevent full insertion into the receptacles.

4. Place the tapered rubber gasket over the HV cable terminal and against the ground shield with smaller diameter towards the pins and notch over the boss.

5. Place a 514A727P1 grounding ring on the cable terminal. When laid on a flat surface, the grounding ring should have corrugations measuring 3/16 inch minimum to the highest point. If necessary, bend it to increase the height, otherwise, the contact pressure may be inadequate to ground through the compound or oil.

   Later HV cables do not require the 514A727P1 grounding rings.

6. If oil is used, pout it into the HV receptacle to a depth of 3/8". Otherwise, coat the end of the HV cable plug with compound to make a round mound equal to the height of the pins. Use a clean, dry wood stick such as a tongue depressor to spread a thin layer of compound over the sides of the plug. It need not cover the surfaces touched by the grounding ring.

7. Insert the HV cable terminal into the receptacle, guiding the boss of the terminal into the slot in the receptacle. Press down on the terminal. If the correct quantity of compound or oil was used, it should ooze up into the space around the grounding ring. Otherwise, clean up and start over again. See Direction 13871A packed with silicone compound.

8. Hold the plastic strain relief in the desired position and tighten the threaded ring with a spanner wrench. Wipe off excess oil or compound that has oozed out.

4–4 SHIELD AGAINST RADIATION

If a collimator is on the X–ray tube unit, close the shutters. Position the tube unit behind a lead protective screen or lead apron(s). Otherwise, cover the tube unit port with sheet lead of 1/16" or more thickness.

4–5 CONNECT THE OSCILLOSCOPE

Do not use a plug adapter to connect the 3–pole plug of the scope power cord to a 115V, 60 Hz outlet. The scope is to be grounded through the power cord.*

*Ungrounded scopes are not permitted unless a warning sign, Form 3549, is posted in the vicinity of the scope and is plainly visible to anyone coming into the area.

1. Connect the Belden No. 8422 (or equivalent) two conductor shielded cables to HV Bleeder terminals.
   White to A (Anode) terminal
   Black to C (Cathode) terminal
   Shield to G (Ground) terminal

2. Connect the scope probes to the two conductor shielded cable leads.

   CH1 – probe to white
   – ground to shield

   CH2 – probe to black
   – ground to shield

4–6 CONNECT GROUND WIRE

Connect a ground wire from G (ground) on the HV Bleeder to G or GND (ground) on the HV transformer.

4–7 CONNECT HIGH VOLTAGE BLEEDER TO AMX MOBILE X–RAY UNITS

1. Remove power by turning key switch and circuit breaker off.

2. Using standard wrench, number 507A935G1 for GE Type II Cable Terminals, remove HV cables from the tube unit.

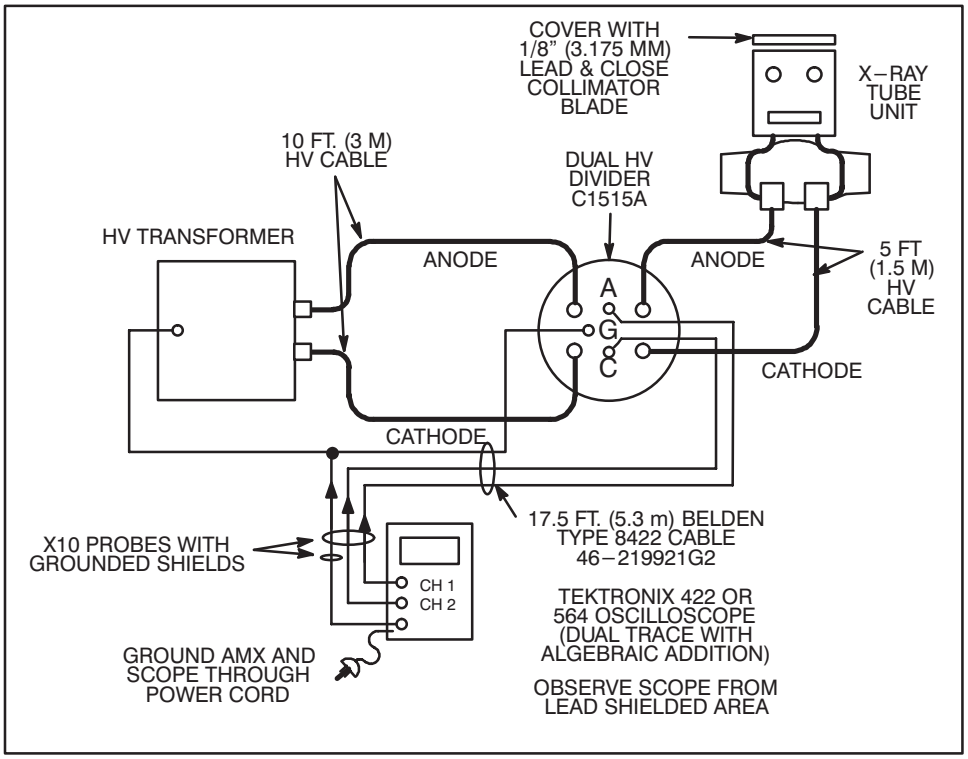
3. See Illustration 8A. Using transformer oil in the cable receptacles, install AMX cables in HV transformer receptacles of the HV Bleeder.

4. Using transformer oil in the HV Bleeder cable receptacles and silicone insulating compound on cable terminations for X–ray tube receptacles, install 5 ft. (1.5 m) cables between HV Bleeder X–ray tube receptacles and the X–ray tube receptacles.

5. Install 17.5 ft. (5.3 m) of Belden Type 8422 shielded coaxial cable, 46–219921G2, between HV Bleeder and oscilloscope probes.

6. Close collimator blades and tape a sheet of 1/8 in. (3 mm) lead over collimator window. Cover tube unit with a lead apron or place lead screens around tube for additional protection from X–rays.

7. Position tube unit about 2 ft. (.6 m) from the floor with the port up.


COVER WITH 1/8" (3.175 MM) LEAD & CLOSE COLLIMATOR BLADE
X–RAY TUBE UNIT
10 FT. (3 M) HV CABLE
DUAL HV DIVIDER C1515A
HV TRANSFORMER
ANODE
ANODE
5 FT (1.5 M) HV CABLE
A
G
C
CATHODE
CATHODE
17.5 FT. (5.3 m) BELDEN TYPE 8422 CABLE 46–219921G2
X10 PROBES WITH GROUNDED SHIELDS
CH 1
CH 2
TEKTRONIX 422 OR 564 OSCILLOSCOPE (DUAL TRACE WITH ALGEBRAIC ADDITION)
GROUND AMX AND SCOPE THROUGH POWER CORD
OBSERVE SCOPE FROM LEAD SHIELDED AREA

CONNECTION OF HIGH VOLTAGE BLEEDER TO AMX MOBILE X–RAY UNITS
ILLUSTRATION 8A

SECTION 5 — OSCILLOSCOPE ADJUSTMENT

5-1 PRELIMINARY ADJUSTMENT

1. Refer to the Oscilloscope Operation and Calibration instructions for adjustment procedures.

2. Compensate the probes. Adjust the trimmer capacitor in the barrel of each probe, if necessary, to obtain flat top square waves on the scope. Only X10 probes with 10 meg ohms resistance are to be used for Bleeder work.

3. Adjust vertical gain control if necessary. Be sure the adjustable volts/div control is in the detent or calibration position.

4. Check Algebraic Addition mode. This is used to display the sum or difference of the signals on Channel 1 (CH1) and Channel 2 (CH2). The gain of the two channels is matched in the calibration procedure. However the deflection in various positions of the VOLTS/DIV switches may vary slightly due to tolerance of the input attenuators and probes involved. For most Bleeder work, the scope will be used at 2V/div, so check at this setting with the channel selector knob in the ALG ADD position.

5-2 FINAL ADJUSTMENTS

After the scope and Bleeder are connected together and the Bleeder is connected to the X-ray unit as shown in Illustrations 3 through 7, but BEFORE USING THE SCOPE FOR ACCURATE kVp READINGS, make the following tests and adjustment.

1. Make a trial low mA, low kvp exposure to be sure the entire set-up is functioning correctly.

2. Put both scope probes on either the anode or cathode terminal of the HV Bleeder.

▲3. Invert Channel 2 with the INVERT switch. Because two identical signals are being subtracted, the trace should be a straight line.

   If the trace shows more than a 3% difference, switch the INVERT switch back to normal. Try reversing the probes to see if the difference is caused by them. Check the probes using the internal calibrator to try to determine which probe is faulty. If the difference is internal to the scope, have both channels calibrated in the 2V/div position by an authorized calibration service or laboratory.

5-3 OVERLOAD PRECAUTIONS

Observe the following general precautions when using the ALG ADD:

1. Do not exceed the voltage rating of the scope.

2. Do not attempt to subtract two signals if either one applied to the scope by itself would drive the trace way off screen as the resulting waveform is likely to be distorted.

3. Keep the position controls set near the center of rotation. Although the display can be returned to the viewing area when the POSITION controls are at either extreme of rotation, the resultant waveform may be distorted.

SECTION 6 - BLEEDER CALIBRATION CHECK

6-1 NO-LOAD TURNS RATIO TEST (SINGLE PHASE X-RAY UNITS)

If X-ray unit to be tested operates on 3-phase power, proceed to 6-2.

This test is to determine the accuracy of the HV Bleeder and oscilloscope combination used on a single phase X-ray unit. It is assumed that the test apparatus was connected to the X-ray unit as shown in Illustration 3.

1. Connect a true RMS reading voltmeter, **one of the types specified earlier in this direction only**, across the HV transformer primary. For convenience use the P1E and P2E terminals at the X-ray control.

2. Select 80 kvp, any mA, 2-1/2 seconds.

3. The secondary to primary turns ratio and kVp per volt data for various X-ray units is given below. Also given is the primary voltage required to produce 80 kVp at no-load, disregarding losses. If the AC meter reading does not correspond with that voltage value, select 70 kVp MAJOR and a kVp MINOR push button or dial setting to get it.

4. Locate the leads from the X-ray tube filament transformers that are connected to 20TB1-XL and 20TB1-XS. Remove them at the latter terminals.

   Some X-ray units have an X-ray tube filament current sensing (monitor) relay interlocking the exposure start circuit. Temporarily install a jumper across the interlock contacts.

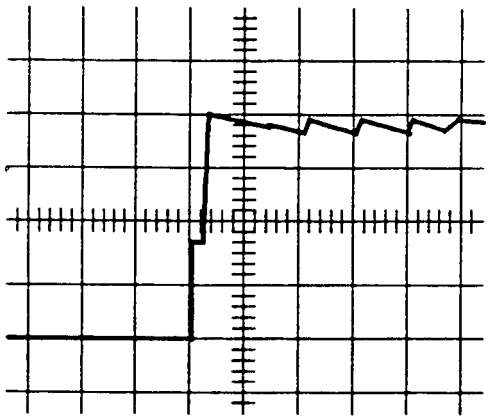
   After the exposure(s) be sure to remove that jumper.

5. Make one or more simulated exposure(s) and compare with Illustration 9. RECONNECT THE WIRES TO 20TB1-XL and 20TB1-XS

SINGLE PHASE UNITS, NO–LOAD TEST

TABLE 1

X-ray Unit	HV Transformer Turns Ratio	KVP Produced Per Volt RMS	Volts Required To Produce 80 KVP
DXR-850 KXR-650	243 to 1	.342	234 +/– 1
MVP Micro DXD: 325; 350-I,II; 525-I,II DXE: 225; 325 DXS: 350; 550; 650-I,II EP: 300; 325 KXD: 225-I,II; 325-I, II, III KXE: 225 KXS: 350; 550 Mobile: 200; 225-I,II, III	463 to 1	.655	122.3 +/– 1
KX-24 KX-23 I or II KX-19 Type 8	400 to 1	.563	142 +/– 1
KX-22 KX-21 I or II KX-20 I or II	512 to 1	.704	110.5 +/– 1
KX-18 I or II KX-17	400 to 1	.563	142 +/– 1



Scope: Tektronix 422 38342-★10
H: 10-ms/div
V: 2-v/div X 10 for probe X 1000 for Bleeder
CH 1: Probe on Bleeder A
Gnd on Bleeder G
CH 2: Probe on Bleeder C
Gnd on Bleeder G
TRIG: DC, EXT
SELECT: ALG ADD

NO LOAD TURNS RATIO TEST

ILLUSTRATION 9

▲ Illustration 9 shows reasonably correct calibration of the scope and Bleeder. Disregard the first peak. Other peaks indicate 79 kVp. If this test indicates more than 5% error it may be due to the test apparatus, such as (a) HV cables between Bleeder and X-ray tube unit or HV transformer more than 5 ft. long, (b) cable between scope probes and Bleeder has wrong capacitance (is other than a shielded, twisted pair), (c) scope is not correctly calibrated, (d) Bleeder is not correctly calibrated.

▲ After rechecking factors (a) to (d) inclusive, if the error is not over 5%, consider the HV Bleeder and scope to be within calibration. If over 5%, refer to subsection 6-3 following.

6-2 LIGHT LOAD TURNS RATIO TEST (THREE PHASE X-RAY UNITS)

If the X-ray unit to be tested operates on single phase power, this procedure does not apply.

This test is to determine the accuracy of the HV Bleeder and oscilloscope combination used on a 3-phase X-ray unit. It is assumed that the test apparatus was connected to the X-ray unit as shown in Illustration 4 or 7 when an SA tube is not used, or Illustration 5 or 6 when an SA tube is used.

1. Connect a true RMS reading voltmeter, one of the types specified in Section 3 of this direction only across one phase of the HV transformer primary. For convenience connect to terminals 2TB2-3 and 2TB3-3 at the power unit.

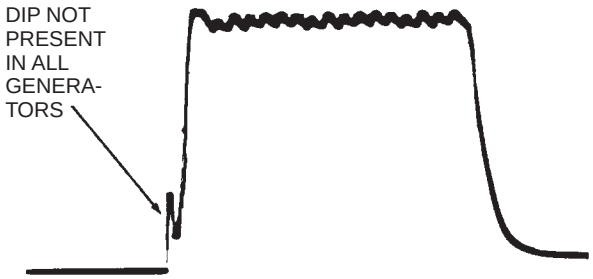
2. In MST, MSI installations, if an SA X-ray tube is not a part of the installation, temporarily install a jumper from 20TB1-SA X-ray control terminal to 20TB1-SO or 20TB1-SU so solenoids in the HV transformer will connect the Bleeder through the SA receptacles. On a Biplane Unit operate it in single plane mode with connections as shown in Illustration 6 or 7.

   CAUTION: When an SA X-ray tube is part of the installation do not install the jumper because anodes of both tubes will rotate and filaments of both tubes will heat. Because neither the 60Hz or 180 Hz Rotor Controller is designed to run two X-ray tube anodes simultaneously, it will blow fuses and the X-ray tube(s) may be damaged. Instead of installing the jumper in this situation, connect the Bleeder in series with the SO X-ray tube unit as shown in Illustration 5. MST-625 is two tube only; use Illustration 6.

3. Select 100 mA, .05 sec., kVp listed in Table 2.

4. To obtain output at 100 mA the AC meter connected in Step 1 must read value shown in Table 2. Energize the X-ray unit and read the meter. If necessary, change the selected kvp to get that voltage.

5. Make an exposure and compare the trace on the scope with Illustration 10.



Scope: Tektronix 422
H: 10–ms/div
V: 2–v/div X 10 for probe X 1000 for Bleeder
CH 1: Probe on Bleeder A
Gnd on Bleeder G
CH 2: Probe on Bleeder C
Gnd on Bleeder G
TRIG: DC, EXT
SELECT: ALG ADD

ILLUSTRATION 10

THREE PHASE UNITS, LIGHT LOAD TEST
TABLE 2

Transformer Models No.	X–ray Unit	kVp	mA	PRI. Volts
11TK20, 20A	DXR–1050	90	100	236 ± 1
11TK20A1, 20B1*	DXR–1250	90	100	236 ± 1
11TK20A1, 20B1*	DXR–750–I, DXR 750–II	90	100	137 ± 1
11TR2A1, B1* 46–146958G1	All MSI–850 and 1250	90	100	247 ± 1
11TR2A1, B1*	DXR–750–III	90	100	138 ± 1
11TK25B1 46–132188G1	MST 625–I and II	90	100	150 ± 1
46–146958G1*	MST 1050–I and II	90	100	247 ± 1
46–146958G1*	MST–750	90	100	145 ± 1
46–188000G1	MPX/SPX 80, 100	90	100	253 ± 1
46–146958G1	MPX 125	90	100	247 ± 1
46–262544G1, G2, G4, G5 & G6	LFX (All Models)	100	10	255 ± 5
46–262544G1 & G2	MVP 60, 80, 100	100	10	255 ± 5

***Note:** Two voltage values appear for transformers 11TK20A1 & B1, 11TR2A1 & B1, and 46–146958G1 because different primary taps are used.

Illustration 10 shows reasonably correct calibration of the scope and Bleeder. If the trace indicates more than 5% error, it may be due to the test apparatus, such as (a) HV cables between Bleeder and transformer more than 5 ft, (b) cable between scope probes and Bleeder has too much capacitance (is other than shielded, twisted pair), (c) scope is not correctly calibrated, (d) Bleeder is not correctly calibrated. After rechecking factors (a) to (d) inclusive, if the error is not over 5%, consider the HV Bleeder and scope to be within calibration. If over 5%, refer to subsection 6–3 following.

6–3 EXCESSIVE CALIBRATION ERROR

If, as the result of no–load or light–load turns ratio tests described above, an error greater than 5% is found, proceed as follows:

8. Recheck all set–up procedures, accuracy of primary voltmeter, and scope calibration.
9. Check scope 2V/div calibration using an external DC source (such as a dry cell battery) with an accurate DC voltmeter on the source. A digital voltmeter is recommended to monitor the DC source. Otherwise, have an authorized calibration service calibrate the scope in the 2V/div position for minimum error.
10. Compare with another HV Bleeder which has been recently calibrated.

If this procedure reveals that the HV Bleeder and/or scope calibration is indeed more than 5% in error, DO NOT ATTEMPT TO RECALIBRATE IT YOURSELF.

Return the HV Bleeder to the manufacturer (internal GE components return to National Service Shop) and request recalibration. The HV Bleeder will be recalibrated on standard factory set–up and returned with calibration curve.

The scope may be recalibrated using local authorized calibration service. The 2V/div setting should be calibrated accurately because it is the position used for kVp accuracy tests.

SECTION 7 — APPLICATION CONSIDERATIONS

The oscillograms in Illustrations 11 to 26 show the variations in waveform peaking that may be seen on single phase X-ray units. The shape of the peaks will change for different models of X-ray units and to some extent for different units of a particular model. The oscillograms for single phase units show that the shape of the peaks changes considerably from low to high kVp exposures and that at high kVp every second pulse is higher than the adjacent one. Therefore, as a general rule for reading kVp on the scope, have at least eight pulses on the display, do not consider the first two pulses and read to the tops of the higher pulses in the remaining group.

CAUTION: If first pulse is peaked and more than 5% higher than the kVp read for the exposure, the timer and X-ray contacting system is not functioning correctly and should be checked and adjusted according to service instructions. Due to X-ray unit characteristics at high kVp the second pulse peak may be up to 5% higher kVp than the remaining ones.

The oscillograms in Sections 9 and 10 show the kind of ripple to be expected on three phase, 12-pulse units. The shape of the ripple changes from low to high kVp exposures. Note the shape of the start of each exposure due to X-ray unit characteristics. On equipment without precontacting circuits, it is normal for this to be up to 10 kVp higher than other peaks of a trace. That peak is not to be considered in reading kVp. Exposures of 0.05 seconds minimum should be taken for a representative trace.

When using the Bleeder for kVp calibration the following points should be kept in mind:

1. Variations in power supply, control and transformer characteristics and HV cable capacitance per foot and length can cause kVp output to be 3 to 4 kVp high or low at the ends of the kVp selection range. Therefore a unit should be most accurate at 60 to 120 kVp. At other kVp values a difference up to 4 kVp should be tolerated. On recent models, see operating manual for tolerance.

2. On X-ray units with a manual voltage compensator it is necessary to check that the indicator reads on the centerline before each exposure and compensate if it is not. Otherwise the input to the X-ray unit is not correct and obviously the output cannot be correct.

3. The mA must be monitored for each exposure used for checking kVp. A 5% variation is permissible. If mA is below normal, kVp will be higher, and vice versa. As an example, if mA is 20% low for a 300 mA selection, the kVp will be 3 to 5 kVp higher than the push button or dial value, even though the X-ray unit is properly calibrated.

4. The overall accuracy of the scope and Bleeder is ± 5% Therefore it should not be used as an absolute standard. The accuracy is high when the turns ratio test described in the previous section is made as a means of establishing a base line and correction factor for a particular kVp calibration set-up.

5. Addition of the 5-ft. connecting HV cables adds resistance to the X-ray tube filament circuit. Therefore it will be necessary to readjust mA when the HV Bleeder is connected, and again when it is disconnected.

6. With the HV Bleeder connected, the two 100 m resistors are paralleling the X-ray tube. Therefore at fluoroscopic mA levels a part of the mA indicated on the mA meter is due to current through the Bleeder resistors and not through the X-ray tube. By calculation the current to be expected is approximately:

   at 150 kVp - .75 mA
   at 100 kVp - .5mA
   at 80 kVp - .4 mA
   at 50 kvp - .25 mA

7. Temperature may affect the Bleeder accuracy. Allow to come to room temperature, and do not operate continuously on Fluoro just before using for calibration.

8. Some equipment such as the MST-625 and Fluoricon 300 contain integral bleeders. Use these for relative readings and troubleshooting, but not for kVp calibration.

9. The Bleeder response does not vary significantly with frequency over the range required for the normal applications described here. However, for accurate results, you must use the twisted shielded pair listed as Item 4 under “Tools and Materials”.

For more information for special applications, contact the General Electric Company.

10. Allow the X-ray unit and connected tube to be properly warmed up before making any measurements. Also, before making decisive measurements of accuracy, allow the X-ray unit and selected tube to have been warmed up continuously for the minimum time interval required. The warm-up requirement is given in the Accuracy Statement of the System Operating Manual or X-Ray Unit Operating Manual.

11. Each connected tube and generator forms a distinct X-ray system. The tube usually limits the range and combination of technic factors. Thus, accuracy of mA and kVp selections apply only within ratings of the tube and focal spot used, even though selections beyond tube ratings are available at the control.

mA and kVp limits for tubes are shown by curves on radiographic rating charts. The charts for domestic use have curves of mA values. Selected mA must never exceed the largest mA value shown. For kVp, the selection must never be less than the lowest kVp on the mA curve, whether it ends at the bottom of the kVp scale or at a definite point above. This minimum kVp limit is necessary for practical space charge compensation to meet accuracy requirements and to preserve filament life. For maximum kVp, Tube Protector circuits are set to limit kVp approximately where the mA curve crosses the selected Time value.

SECTION 8 — WAVEFORM EXAMPLES (Single Phase X-ray Units)

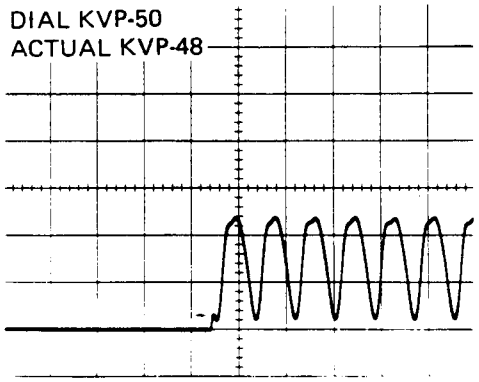
8-1 25 mA WAVEFORMS

Illustrations 11 to 14 below show how the waveshape changes when the kVp is varied from 50 to 150 with the mA constant at 25 mA. Variations in power supply characteristics and control, HV transformer and HV cables can cause output at high and low kVp to be as much as 3 to 4 kVp high or low. The X-ray unit will be most accurate from 60 to 120 kVp. At other kVp values a difference of up to 4 kVp should be tolerated.

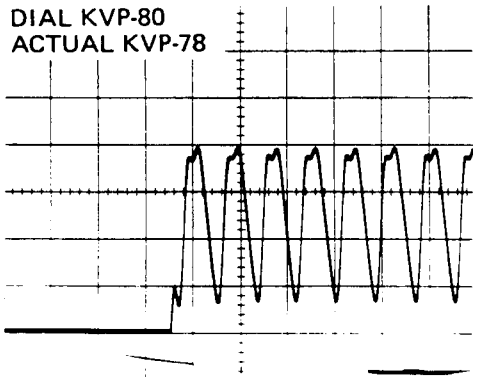
Scope data for all oscillograms on this page is as follows:

Scope: Tektronix 422
H: 10 ms/div
V: 2V/div x 10 for probe x 1000 for Bleeder
Trigger: DC, EXT
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*

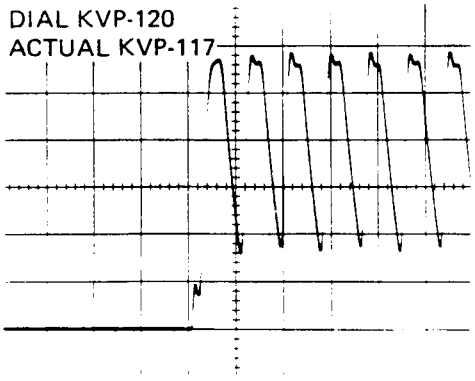
*Which must be grounded to HV transformer G also.



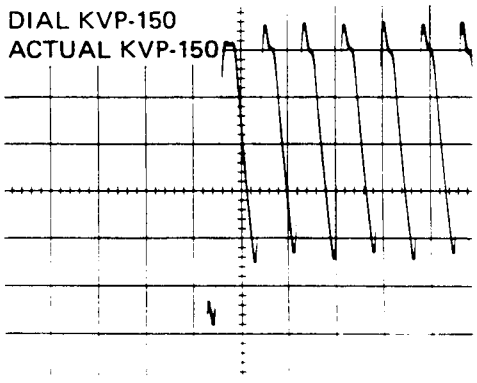
EXP: 25 mA, 50 kVp, 1/5 Sec 18838-P10
ILLUSTRATION 11



EXP: 25 mA, 80 kVp, 1/5 Sec 18839-P10
ILLUSTRATION 12



EXP: 25 mA, 120 kVp, 1/5 Sec 18840-P10
ILLUSTRATION 13



EXP: 25 mA, 150 kVp, 1/5 Sec 18841-P10
ILLUSTRATION 14

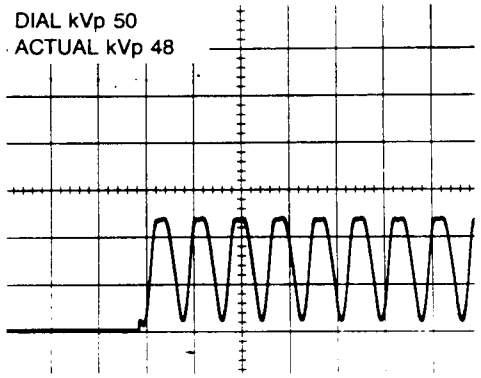
8-2 50 mA WAVEFORMS

Illustrations 15 to 18 below show how the waveshape changes when the kVp is varied from 50 to 150 with the mA constant at 50 mA. Variations in power supply characteristics and control, HV transformer and HV cables can cause output at high and low kVp to be as much as 3 to 4 kVp high or low. The X-ray unit will be most accurate from 60 to 120 kVp. At other kVp values a difference of up to 4 kVp should be tolerated.

Scope data for all oscillograms on this page is as follows:

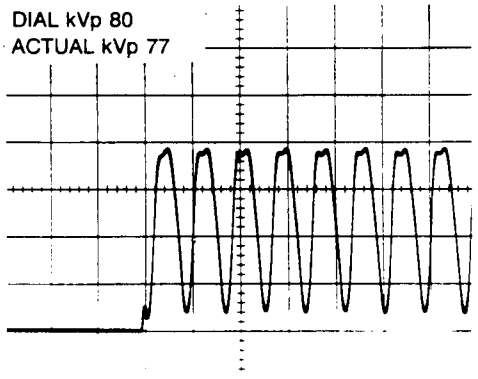
Scope: Tektronix 422
H: 10 ms/div
V: 2V/div x 10 for probe x 1000 tor Bleeder
Trigger: DC, EXT
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*

*Which must be grounded to HV transformer G also.



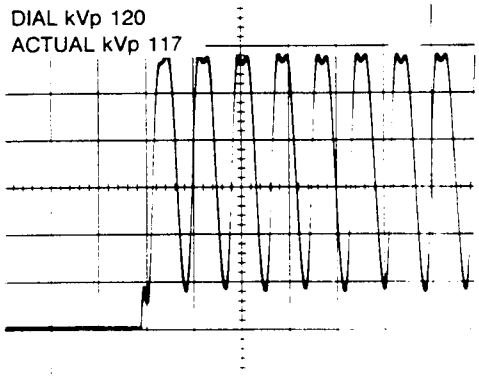
18842-P10

EXP: 50 mA, 50 kVp, 1/10 Sec
ILLUSTRATION 15



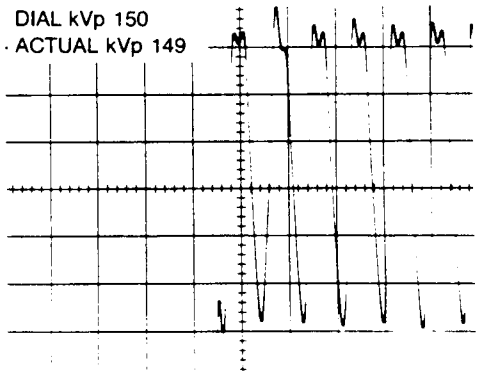
18843-P10

EXP: 50 mA, 80 kVp, 1/10 Sec
ILLUSTRATION 16



18906-P10

EXP: 50 mA, 120 kVp, 1/10 Sec
ILLUSTRATION 17



18844-P10

EXP: 50 mA, 150 kVp, 1/10 Sec
ILLUSTRATION 18

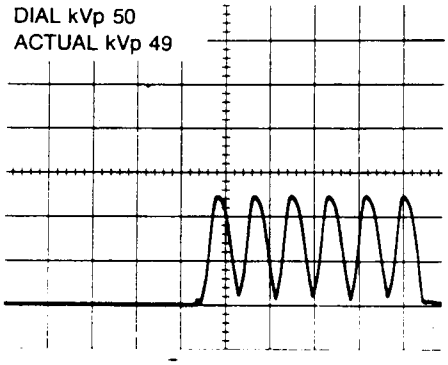
8-3 200 mA WAVEFORMS

Illustrations 19 to 22 below show how the waveshape changes when the kVp is varied from 50 to 150 with the mA constant at 200 mA. Variations in power supply characteristics and control, HV transformer and HV cables can cause output at high and low kVp to be as much as 3 to 4 kVp high or low. The X-ray unit will be most accurate from 60 to 120 kVp. At other kVp values a difference of up to 4 kVp should be tolerated.

Scope data for all oscillograms on this page is as follows:

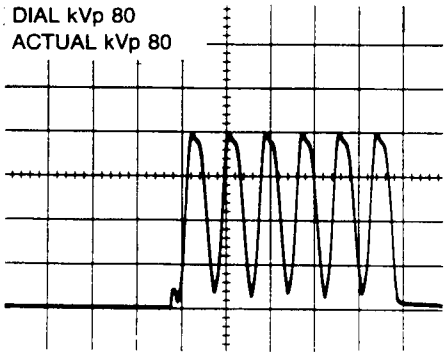
Scope: Tektronix 422
H: 10 ms/div
V: 2V/div x 10 for probe x 1000 for Bleeder
Trigger: DC, EXT
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*

*Which must be grounded to HV transformer G also.



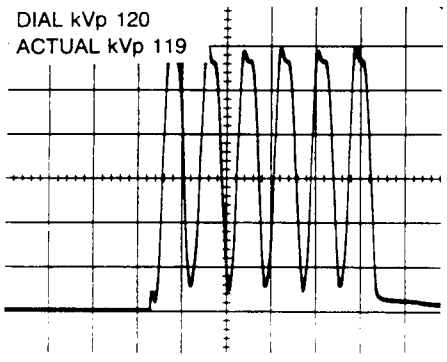
18845-P10

EXP: 200 mA, 50 kVp, 1/20 Sec
ILLUSTRATION 19



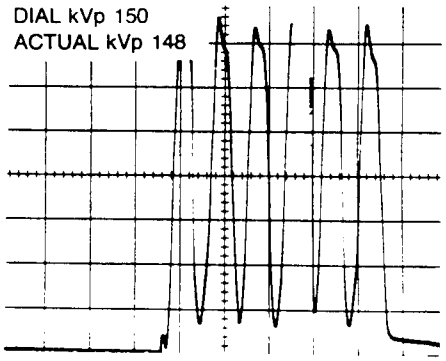
18846-P10

EXP: 200 mA, 80 kVp, 1/20 Sec
ILLUSTRATION 20



18847-P10

EXP: 200 mA, 120 kVp, 1/20 Sec
ILLUSTRATION 21



18848-P10

EXP: 200 mA, 150 kVp, 1/20 Sec
ILLUSTRATION 22

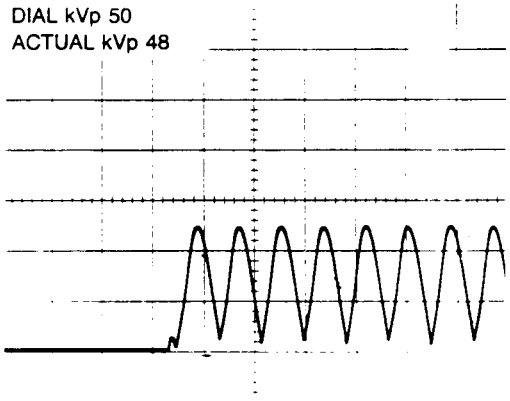
8-4 300 mA WAVEFORMS

Illustrations 23 to 26 below show how the waveshape changes when the kVp is varied from 50 to 150 with the mA constant at 300 mA. Variations in power supply characteristics and control, HV transformer and HV cables can cause output at high and low kVp to be as much as 3 to 4 kVp high or low. The X-ray unit will be most accurate from 60 to 120 kVp. At other kVp values a difference of up to 4 kVp should be tolerated.

Scope data for all oscillograms on this page is as follows:

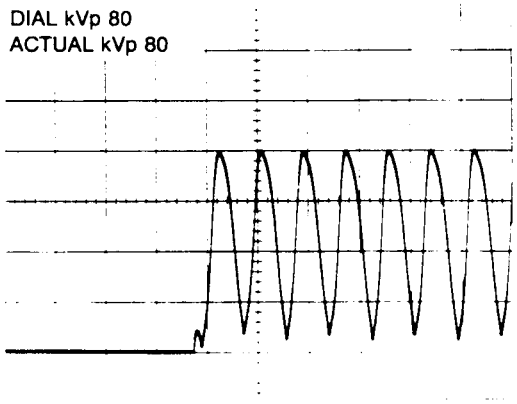
Scope: Tektronix 422
H: 10 ms/div
V: 2V/div x 10 for probe x 1000 for Bleeder
Trigger: DC, EXT
CH1 – Probe on Bleeder A, GND on Bleeder G*
CH2 – Probe on Bleeder C, GND on Bleeder G*

*Which must be grounded to HV transformer G also.



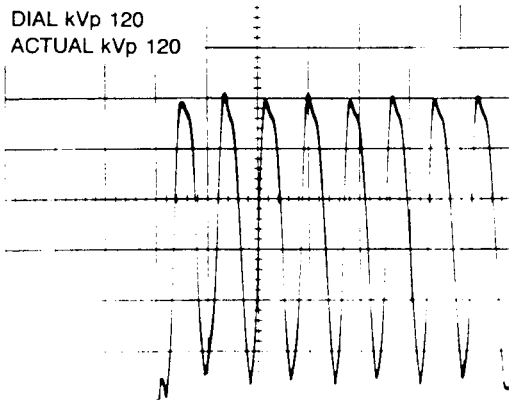
18849-P10

EXP: 300 mA, 50 kVp, 1/15 Sec
ILLUSTRATION 23



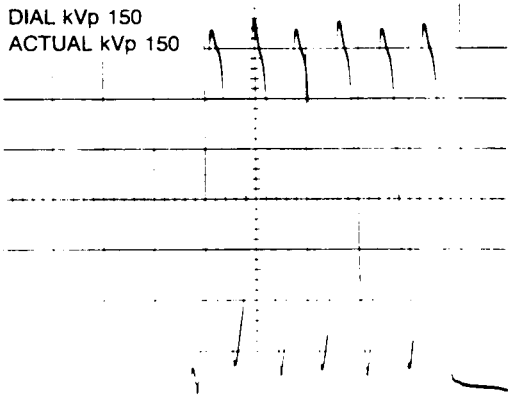
18850-P10

EXP: 300 mA, 80 kVp, 1/15 Sec
ILLUSTRATION 24



18851-P10

EXP: 300 mA, 120 kVp, 1/15 Sec
ILLUSTRATION 25



18852-P10

EXP: 300 mA, 150 kVp, 1/15 Sec
ILLUSTRATION 26

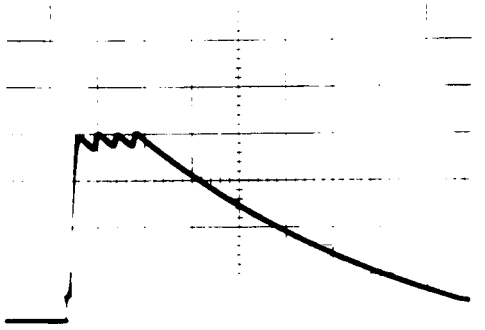
8-5 FLUORO WAVEFORMS

Illustrations 27 to 31 below show excellent kVp calibration for fluoroscopy. Illustrations 27, 28 and 29 show how the ripple voltage increases when kVp is held constant at 80 kVp and mA is increased. Also note the change in slope of voltage decay at the different loads. Illustrations 30 and 31 show typical output of a well calibrated unit at 60 and 120 kVp for a load of 3 mA.

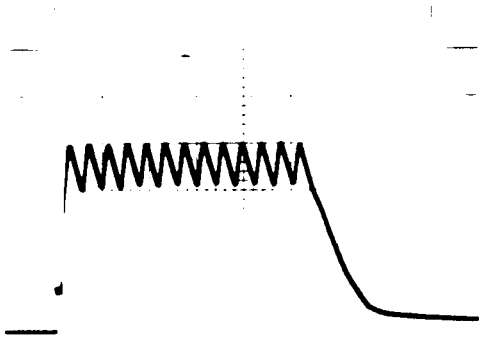
Scope data for all illustrations on this page:

Scope: Tektronix 422
H: 20 ms/div
V: 2V/div x 10 for probe x 1000 for Bleeder
Trigger: DC, EXT
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*

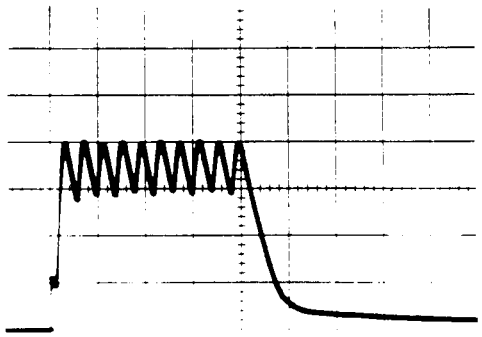
*Which must be grounded to HV transformer G also.



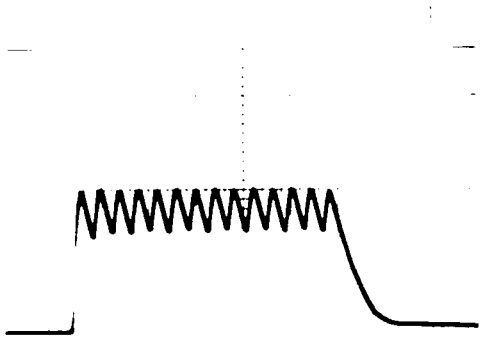
80 kVp, 1 mA 18853-P10
ILLUSTRATION 27



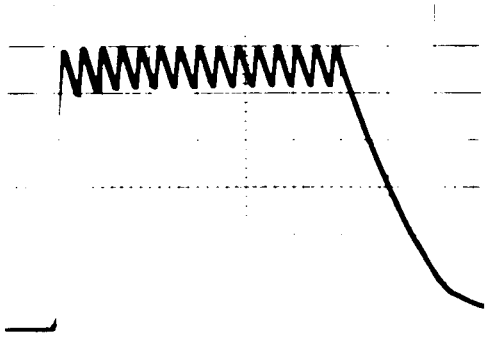
80 kVp, 3 mA 18854-P10
ILLUSTRATION 28



80 kVp, 5 mA 18855-P10
ILLUSTRATION 29



60 kVp, 3 mA 18856-P10
ILLUSTRATION 30



120 kVp, 3 mA 18857-P10
ILLUSTRATION 31

SECTION 9 — WAVEFORM EXAMPLES (For 3-Phase X-ray Units without Precontacting Circuits)

9-1 ANODE, CATHODE AND ADDED WAVE-FORMS

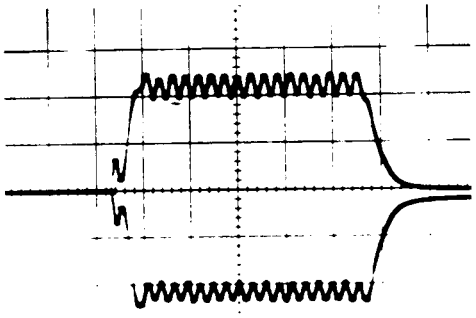
Illustrations 32 to 35 below show the difference when the anode to ground and cathode to ground voltages are observed in the chopped and algebraic addition modes. Note that when each channel is observed separately (chopped) the anode voltage is 48 kVp and the cathode voltage is 47 kVp for a peak to peak voltage of 95 kVp. However, because the peaks of anode voltage are about in phase with the valleys of cathode voltage, the voltage across the X-ray tube is 90 kVp as shown in Illustration 33.

Waveforms on following pages will show that the first pulse of each exposure is higher than any other peaks by 4 to 8 kVp. Illustrations 34 and 35 show how this affects the shortest exposure possible (.003 sec.) on a DXR-1050 or DXR-1250. Illustration 34 was made in the chopped mode. Note that anode voltage was 58 while cathode voltage was 66 for a total of 124 kVp. When added by the scope, the kVp across both was 124. This is characteristic of the X-ray unit because the same one was used to obtain the waveforms of Illustration 32 which show the anode and cathode voltages balanced.

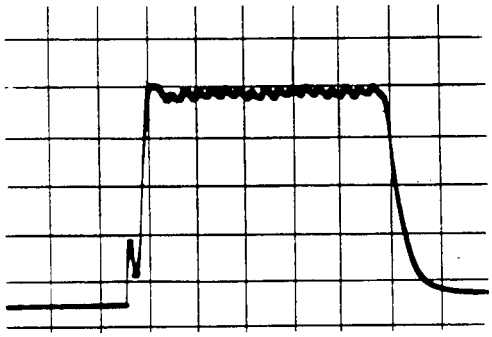
Scope data for all oscillograms on this page is as follows:

Scope: Tektronix 422
H: 10 ms/div
V: 2V/div x 10 for probe x 1000 for Bleeder
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*
Trigger: DC, EXT
Select: ALG ADD

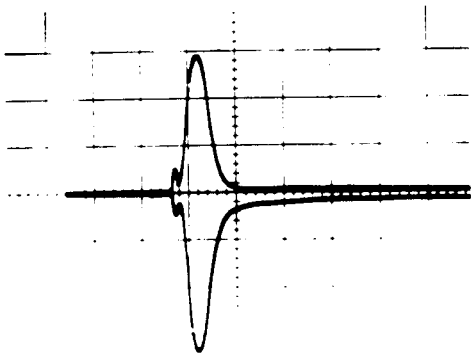
*Which must be grounded to HV transformer G also.



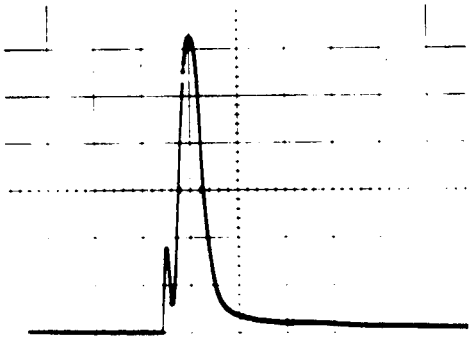
100S mA, 90 kVp, 0.05 Sec, CHOPPED 18858-P10
ILLUSTRATION 32



100S mA, 90 kVp, 0.05 Sec, ALG ADD 18859-P10
ILLUSTRATION 33



200L mA, 120 kVp, 0.003 Sec, CHOPPED 18860-P10
ILLUSTRATION 34



200L mA, 120 kVp, 0.003 Sec, ALG ADD 18861-P10
ILLUSTRATION 35

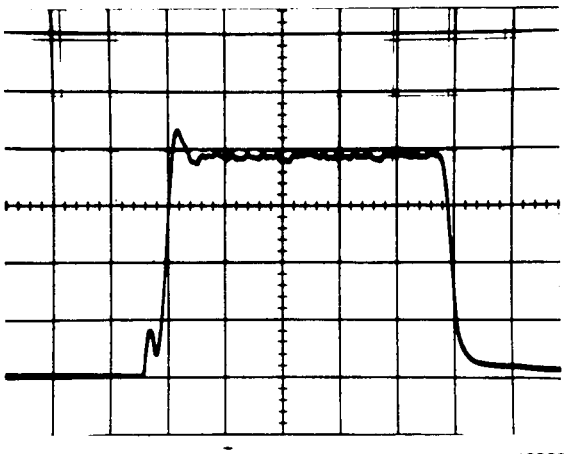
9-2 80 kVp WAVEFORMS

Illustrations 36 to 39 below show precise calibration of an X-ray unit, that is, the kVp is maintained relatively constant at 80 kVp despite the change in load from 400 to 1000 mA.

Scope data for all oscillograms on this page is as follows:

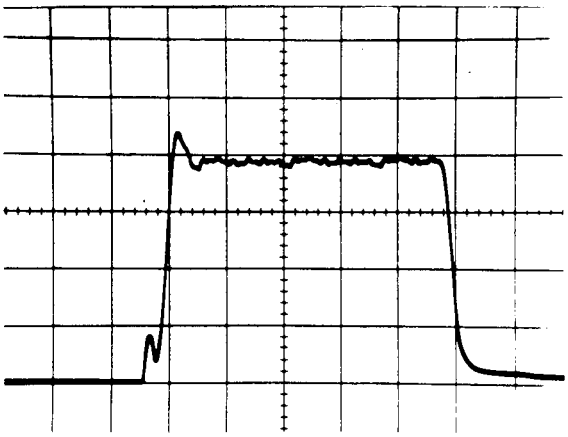
Scope: Tektronix 564
H: 10 ms/div
V: 2V/div x 10 for probe x 1000 for Bleeder
Trigger: DC, EXT
Select: ALG ADD
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*

*Which must be grounded to the HV transformer also.



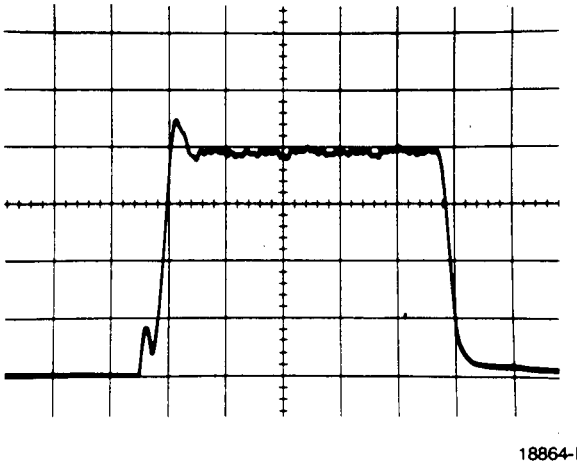
18862-P10

EXP: 400L mA, 80 kVp, 0.05 Sec
ILLUSTRATION 36



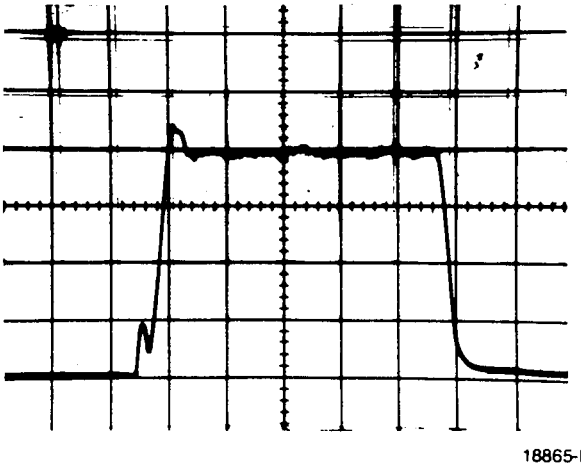
18863-P10

EXP: 500L mA, 80 kVp, 0.05 Sec
ILLUSTRATION 37



18864-P10

EXP: 700L mA, 80 kVp, 0.05 Sec
ILLUSTRATION 38



18865-P10

EXP: 1000L mA, 80 kVp, 0.05 Sec
ILLUSTRATION 39

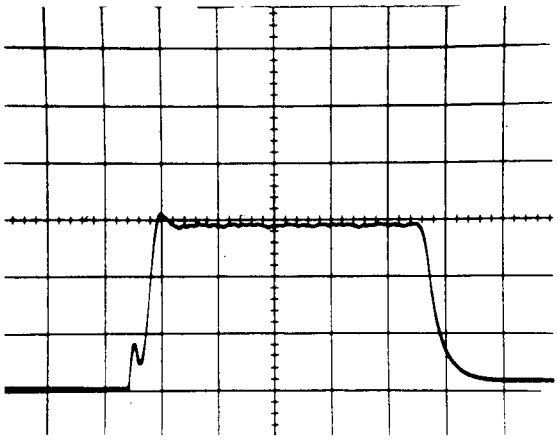
9-3 25 AND 100 mA WAVEFORMS

Illustrations 40 to 43 below show changes in waveshape as the mA is held constant at 100S mA and the kVp is changed from 60 to 150.

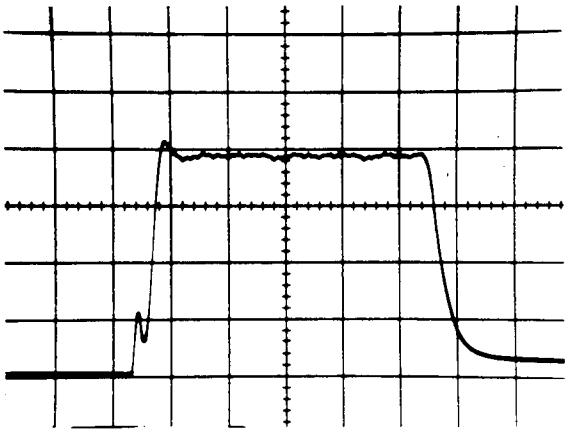
Scope data for all oscillograms on this page is as follows:

Scope: Tektronix 564
H: 10 ms/div
V: 2V/div x 10 for probe x 1000 for Bleeder
Trigger: DC, EXT
Select: ALG ADD
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*

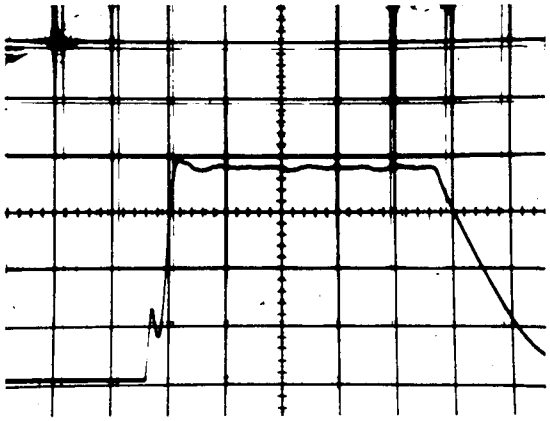
*Which must be grounded to the HV transformer also.



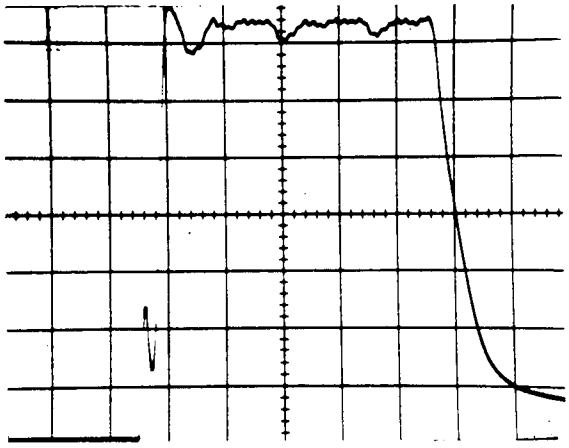
EXP: 100S mA, 60 kVp, 0.05 Sec 18866-P10
ILLUSTRATION 40



EXP: 100S mA, 80 kVp, 0.05 Sec 18867-P10
ILLUSTRATION 41



18868-P10
EXP: 25S mA, 80 kVp, 0.05 Sec
ILLUSTRATION 42



18869-P10
EXP: 100S mA, 150 kVp, 0.05 Sec
ILLUSTRATION 43

9-4 500 mA WAVEFORMS

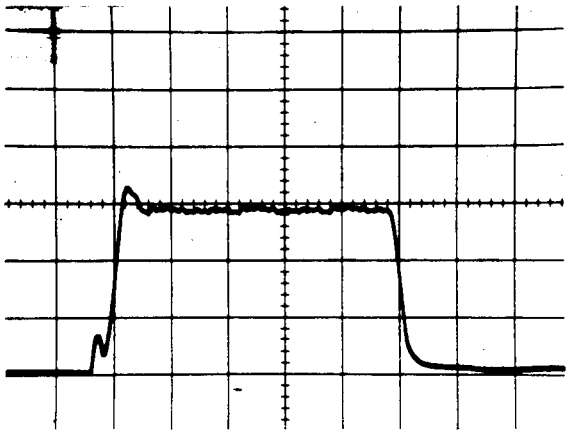
Illustrations 44 to 46 show changes in waveshape as the mA is held constant at 500 mA but the kVp is changed from 60 to 150.

Scope data for all oscillograms on this page is as follows:

Scope: Tektronix 564
H: 10 ms/div
V: 20V/div x 10 for probe x 1000 for Bleeder
Trigger: DC, EXT
Select: ALG ADD
CH1 — Probe on Bleeder A, GND on Bleeder G*
CH2 — Probe on Bleeder C, GND on Bleeder G*

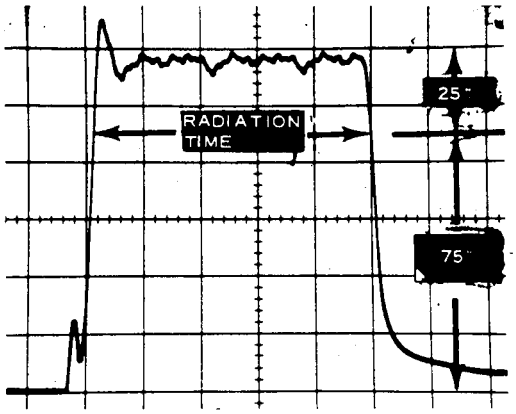
*Which must be grounded to the HV transformer also.

Time values on the push buttons of the X-ray control are in RADIATION TIME. These HV secondary waveforms can be used to check the exposure time. Read the ms/div times the number of divisions at 75% of the height of the waveform as shown below.



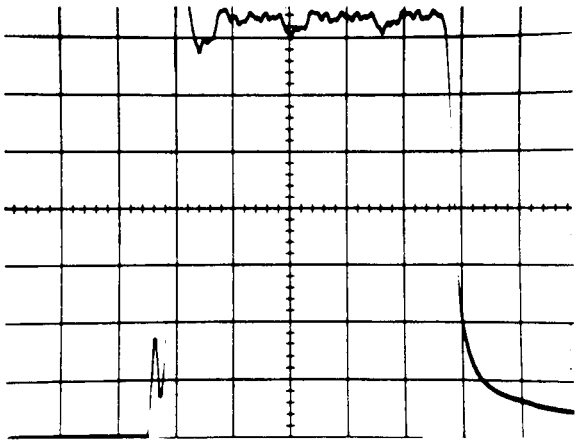
18870-P10

EXP: 500L mA, 60 kVp, 0.05 Sec
ILLUSTRATION 44



18871-P10

EXP: 500L mA, 120 kVp, 0.05 Sec
ILLUSTRATION 45



18872-P10

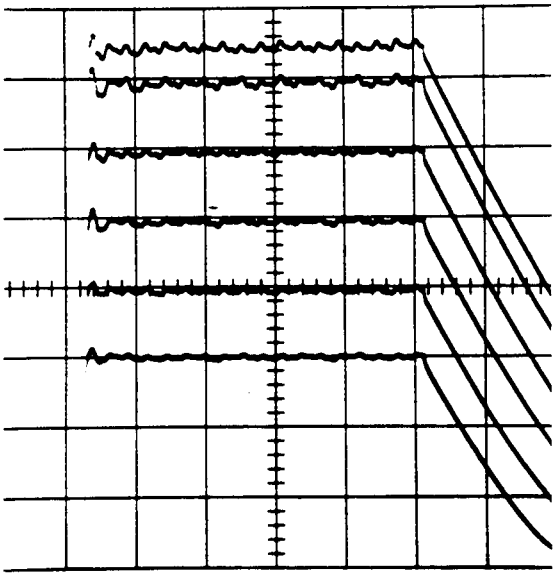
EXP: 500L mA, 150 kVp, 0.05 Sec
ILLUSTRATION 46

SECTION 10- WAVEFORM EXAMPLES (Three Phase X-ray Units with Precontacting Circuits)

illustrations 47 to 56 following were taken on an MSI 1250-lV which had been carefully adjusted for optimum precontacting and proper kVp calibration. Note how waveforms rise rapidly with minimum of undershoot and overshoot. The MSI 1250-IV has three independent adjustments; earlier MSI models have two adjustments, and will not produce the same results. See individual model service manuals for limits.

Ripple depends upon power line phase balance. Since no special phase sequence is required for the transformer of MSI units leads may be interchanged at the transformer to obtain minimum ripple.

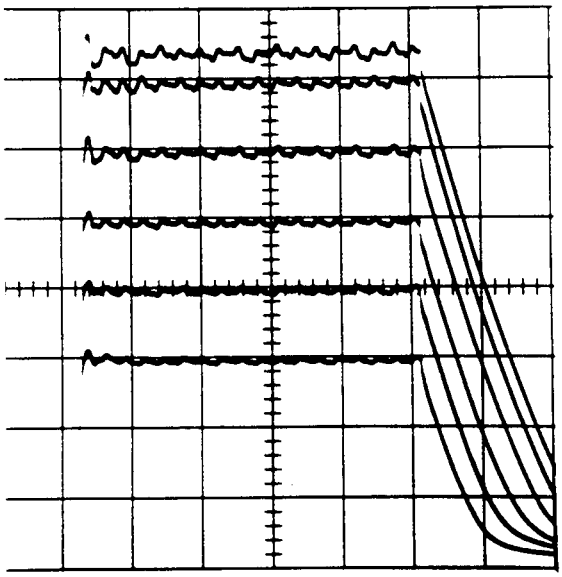
Exposure time is defined as the pulse width at 75% of maximum amplitude. Maximum amplitude is the kVp, and is measured to the highest peak, not including the initial overshoot (if any). Waveforms below were self-triggered, and do not show the scope “Zero”. Use of the triggering circuit of Illustration 8 permits viewing the “zero” for assurance that it has not drifted, and will result in more accurate kVp measurements.



18873-P10

25 mA .05 SEC 10 MS/CM 20 V/CM

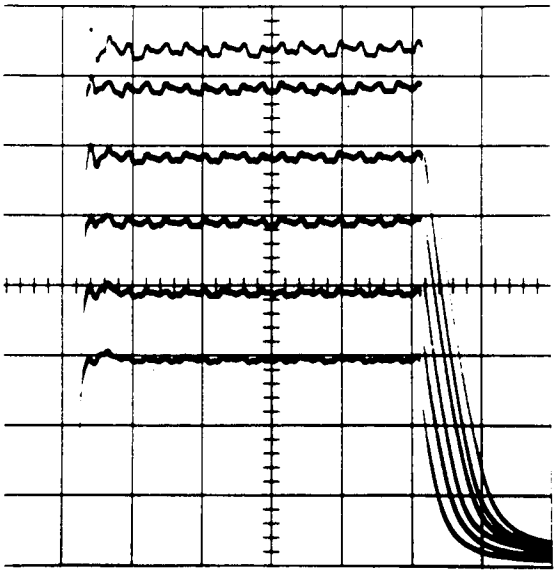
ILLUSTRATION 47



18874-P10

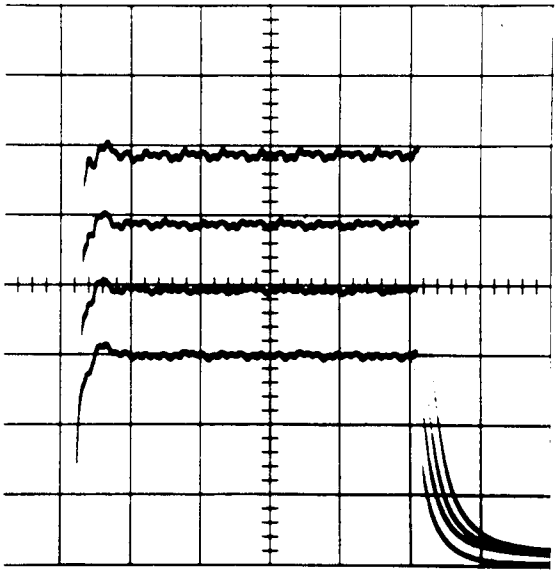
50 mA .05 SEC 10MS/CM 20 V/CM

ILLUSTRATION 48



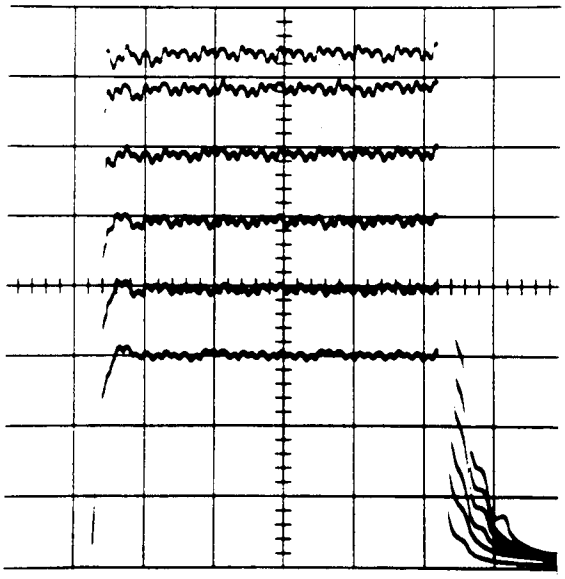
18875-P10

100 mA .05 SECOND 10 MS/CM 20 V/CM
ILLUSTRATION 49



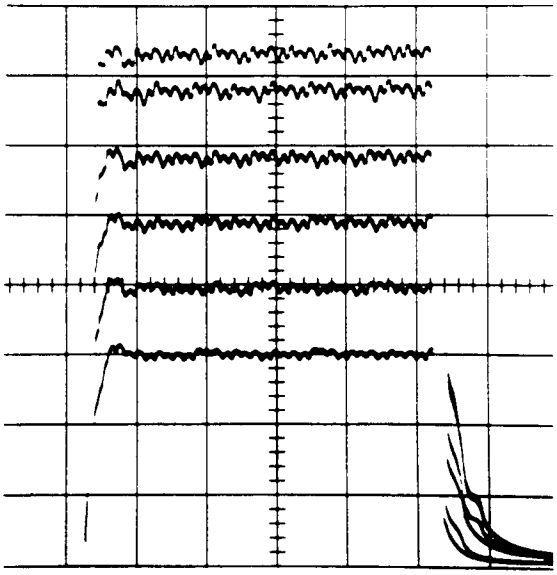
18876-P10

200 mA .05 SECOND 10 MS/CM 20 V/CM
ILLUSTRATION 50



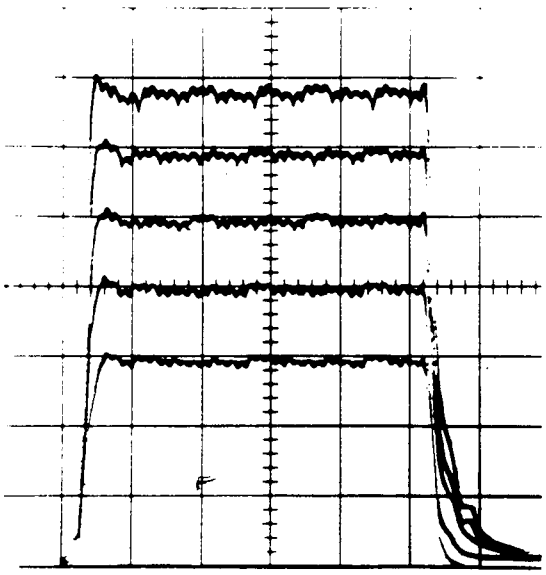
18877-P10

300 L mA .05 SECOND 10 MS/CM 20 V/CM
ILLUSTRATION 51



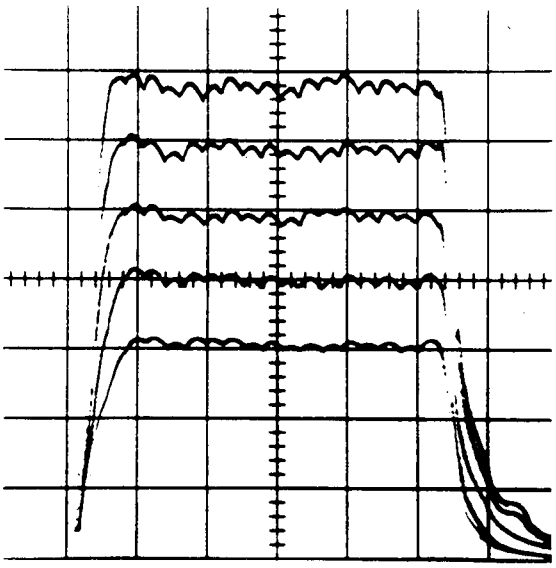
18878-P10

400 mA .05 SECOND 10 MS/CM 20 V/CM
ILLUSTRATION 52



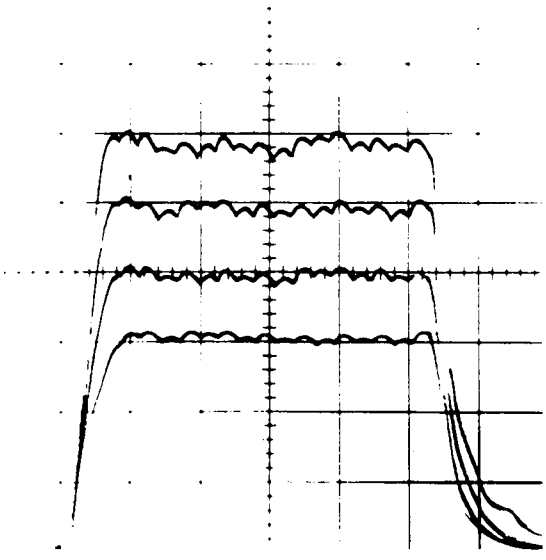
18879-P10

600 mA .05 SECOND 10 MS/CM 20 V/CM
ILLUSTRATION 53



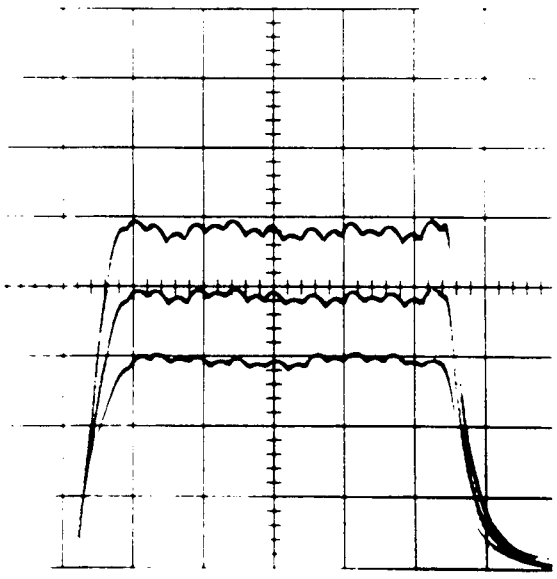
18880-P10

800 mA .025 SECOND 5 MS/CM 20 V/CM
ILLUSTRATION 54



18881-P10

1000 mA .025 SECOND 5 MS/CM 20 V/CM
ILLUSTRATION 55



18882-P10

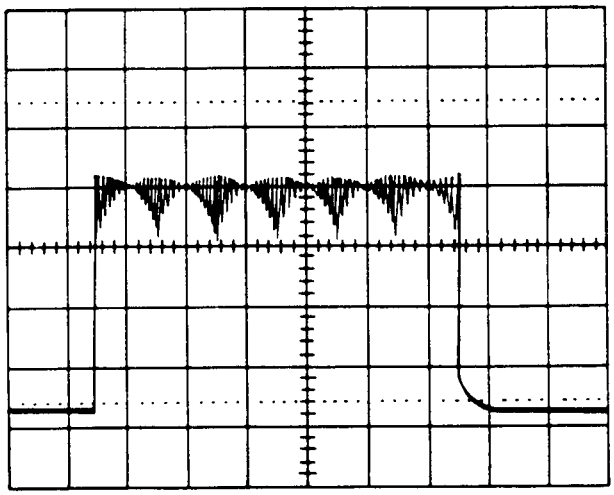
1200 mA .025 SECOND 5 MS/CM 20 V/CM
ILLUSTRATION 56

SECTION 11 — WAVEFORM EXAMPLES (AMX)

Illustrations 57 and 58 depict kVp waveforms of an AMX. The pictures illustrate “Aliasing” on a digital storage scope. This problem arises when the displayed waveform contains frequency components about half or greater than half of the sampling frequency. A frequency of 500, 800 or 1000 Hz, from the inverter, is part of the kVp waveform and causes the unusual display of Illustration 57 since the sampling rate is about 1000 samples per second. Similar displays will be seen with either the Tektronix 468 Digital or 465 MOD UC scopes.

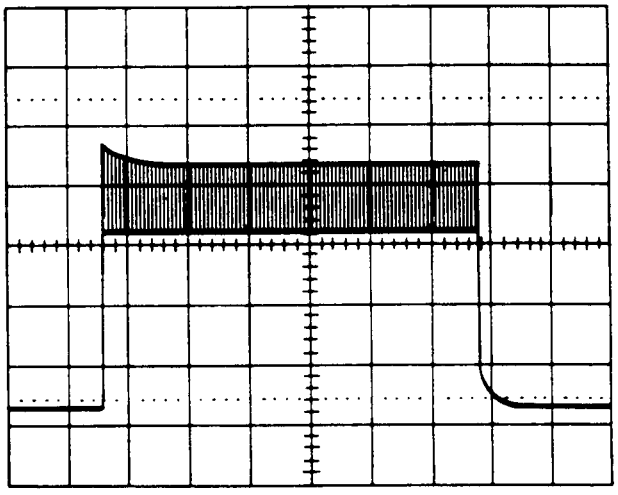
Illustration 58 shows the waveform obtained by using the 468 scope in the “Envelope Mode.” This mode uses a sampling frequency of 25 MHZ and avoids “Aliasing.” The picture is identical to that which would be observed on a standard CRT type storage scope such as the Hewlett Packard 1741A.

Scope: Tektronix 468 Digital
H: 50 msec/div
V: 2V/div x 10 for probe, x 1000 for Bleeder
Trigger, Internal, DC, post trigger
Select: ALG ADD
Exposure: 80 kVp, 30 mAs, excessive overshoot on leading edge.



33394-D01

NORMAL STORAGE — ALIASING
ILLUSTRATION 57



33398-D01

ENVELOPE STORAGE — NO ALIASING
ILLUSTRATION 58

SECTION 12 — WAVEFORM EXAMPLES (Pulsed Fluoro/Cine Systems)

12-1 A DEFINITION FOR CINE kVp

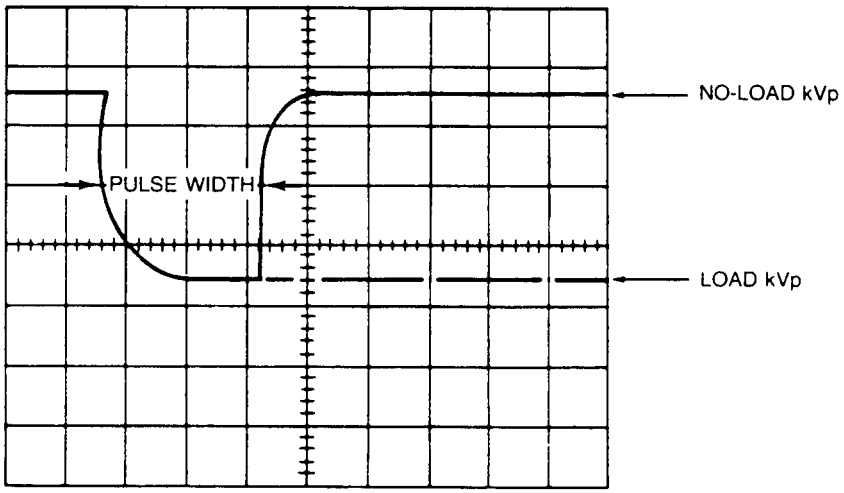
Since the X-ray tube in a cine system has very limited accessibility, and since it has a 4 terminal HV cable instead of a 3 terminal cable like a radiographic tube, we must measure the kVp at the HV transformer.

Connect the HV divider as per Illustration 6. Follow the instruction in the appropriate generator or intensifier service manual for setting up the equipment.

The waveform will appear as the simulated waveform of Illustration 59; this waveform has been expanded vertically for convenience. The kVp of interest is called the load kVp and is measured on the lower portion of the waveform after a stable level has been reached. The time required to reach a stable kVp will vary with the mA loading, but generally it will not be less than 2 msec. Therefore, run the system at a pulse width of at least 4 msec. As this presents a considerable heat unit load be careful not to overstress the X-ray tube with repeated tests.

Other methods of defining cine kVp, such as the kVp observed after a short fixed delay or the kVp observed at the 75 percent point on the waveform, do not provide reproducible results due to the variable nature of the shape of the waveform.

For reference, the pulse width is measured at a point on the waveform midway between the no-load and load kVp values.



SIMULATED WAVEFORM
ILLUSTRATION 59

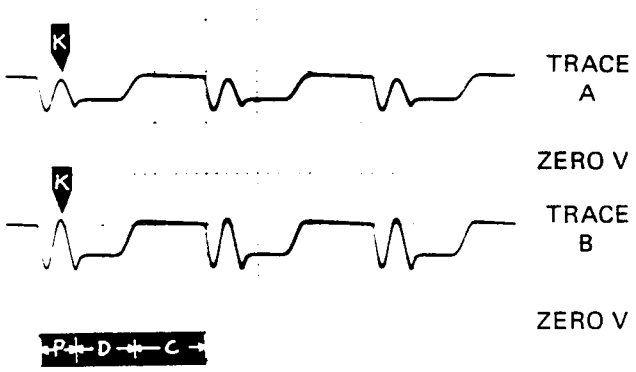
12-2 PULSED FLUORICON, WITHOUT PULSE SYSTEM CAPACITOR

The following applies to both single phase and three phase X-ray units. The waveforms below show how the HV Bleeder and oscilloscope can be used to determine optimum output or to detect a malfunction when the X-ray exposures occur during 4 ms turn-on pulses to a grid controlled X-ray tube.

Trace A of Illustration 60 shows anode to ground voltage. Trace B shows cathode to ground voltage. Period P is the 4 ms pulse interval. Period D is the time when the HV cables are partly discharged and Period C is the interval when the HV cables are charged to the no-load kVp level. Point K (two shown) is the pulse which produces radiation during the 4 ms interval. The top of this pulse is the load kVp during the exposure. The illustrations shows no-load kVp of 39 for anode and 41 for cathode, and load kVp 37 for anode and 42 for cathode to ground. The greater negative excursion of the cathode wave when load was applied results from higher total capacitance of the cathode HV cable.

Illustration 61 shows the addition of the two traces in Illustration 60. No-load kVp is 80 and load kVp is practically the same.

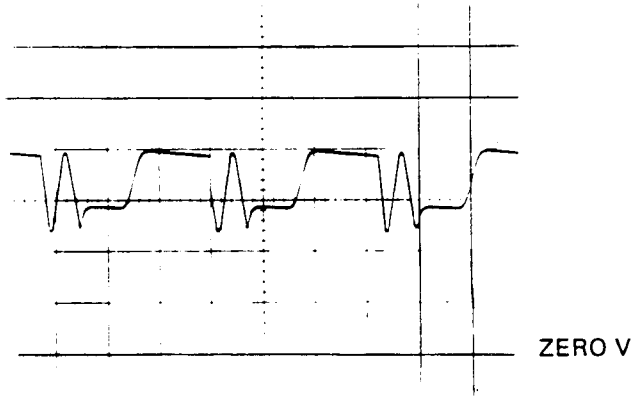
CH1: Probe: HV Bleeder, Anode
GND: HV Bleeder, Gnd
CH2: Probe: HV Bleeder, Cathode
GND: HV Bleeder, Gnd
H: 5 ms/div
V: 2V/div x 10 (probe) x 1000 (Bleeder)
Mode: Chopped
Trigger: Int, Auto
Exp: 80 kVp, 20 mA, 4 ms, pulses at 60 pps



18883-P10

ILLUSTRATION 60

CH1: Probe: HV Bleeder, Anode
GND: HV Bleeder, Gnd
CH2: Probe: HV Bleeder, Cathode
GND: HV Bleeder, Gnd
H: 5 ms/div
V: 2V/div x 10 (probe) x 1000 (Bleeder)
Mode: Algebraic Add
Trigger: Int, Auto
Exp: 80 kVp, 20 mA, 4 ms pulses at 60 pps



18884-P10

ILLUSTRATION 61

12-3 RADIATION OUTPUT

For Illustration 62, Trace A below, a phototube pick-up device was placed about 18" from the X-ray tube window. It was not calibrated in terms of R-output, but is useful to show the relative R from one instant to another during one 4 ms pulse. Trace B is the Anode to Ground kVp.

Trace A of Illustration 62 shows the radiation output during a 4 ms pulse shown as Period P. Note that the radiation level follows the positive pulse of Trace B; therefore, to obtain maximum radiation during a pulse the kVp must be kept at the selected level (80 kVp in this case) during the entire pulse interval. Practically, this cannot be attained. However, when filter-capacitors are added to the HV transformer secondary there is a marked improvement and the R-output increases 30 to 40% over that shown in Illustration 62. Filter-capacitor operation is shown in Section 12-5.

Trace A — CH1
Probe: Output of phototube pick-up in X-ray beam
GND:
H: 2 ms/div
V: As required
Trace B — CH2
Probe: HV Bleeder, Anode
GND: HV Bleeder, GND
H: 2 ms/div
V: 2V/div x 10 (probe) x 1000 (Bleeder)
Mode: Chopped
Trigger: DC, Int, Auto
Exp: 80 kVp, 20 mA, 4 ms at 60 pps

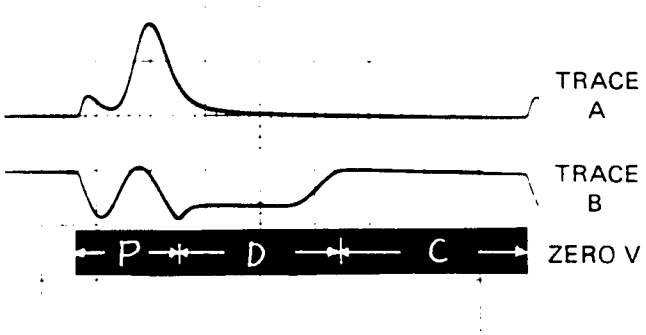


ILLUSTRATION 62 18885-P10

12-4 PULSE PHASING

Illustration 63 shows correct phase relationship of the Fluoricon pulse generator with the HV primary power pulses. Maximum R-output cannot be obtained unless the relationship is as shown.

Improper phase relationship results in lower output, excessively high kVp peaks, excessive HV transformer primary currents and lower mA for a given filament volt-age.

Trace A — CH1
Probe: HV Bleeder, Anode
GND: HV Bleeder, GND
H: 5 ms/div
V: 2V/div x 10 (probe) x 1000 (Bleeder)
Mode: Chopped
Trigger: DC, Int, Auto

Trace B — CH2
Probe: To primary of isolation transformer which has
GND: secondary connected to P1 and P2 of X-ray control
H: 5 ms/div
V: As required
Exp: 80 kVp, 20 mA, 4 ms at 60 pps

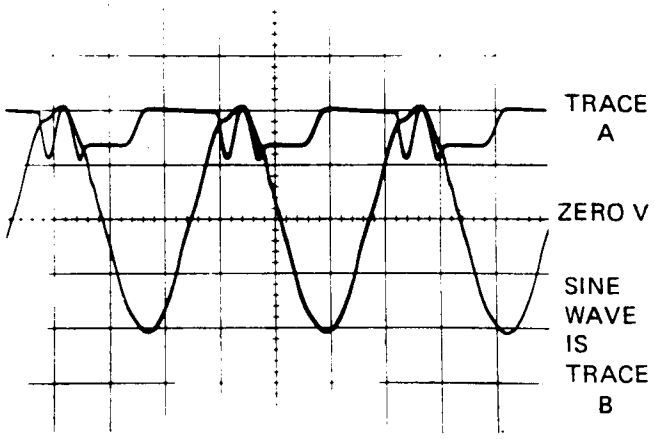


ILLUSTRATION 63 18886-P10

Illustrations 64, 66, and 68 show normal and incorrect Fluoricon pulse phase adjustments. Illustrations 65, 67, and 69 show the outputs resulting from such phase relationship.

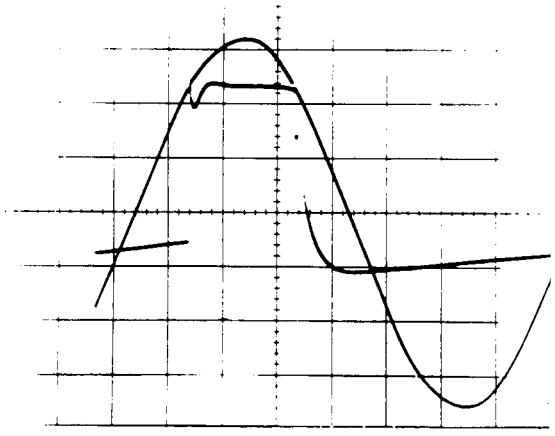
Scope settings for all these illustrations are:

CH1 — Probe: Pulse Generator Chassis
Pin 6 of V8, 20V/div
CH2 — Probe: Pin 8 of V4B, 1 OV/div
GND: Pulse Generator Chassis terminal 7
H: 2 ms/div
Trigger: CH1, AC, +Auto
Mode: Chopped

Remove Fuse F4 in the Remote Control Cabinet for phasing measurements and adjustments.

CH1 — Probe: HV Bleeder, Anode
CH2 — Probe: HV Bleeder, Cathode
GND: HV Bleeder, GND
H: 5 ms/div
V: 2 x 10 (probe) x 1000 (Bleeder)
Mode: ALG ADD
Trigger: DC, Int, Auto

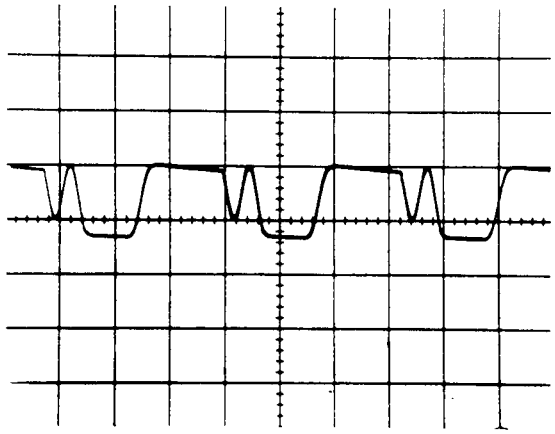
NORMAL PHASING



18887-P10

ILLUSTRATION 64

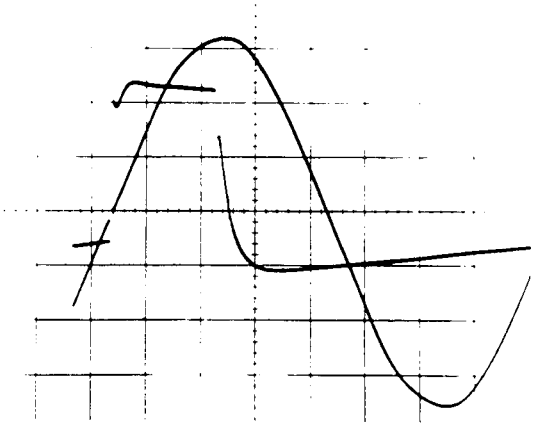
OUTPUT



18888-P10

ILLUSTRATION 65

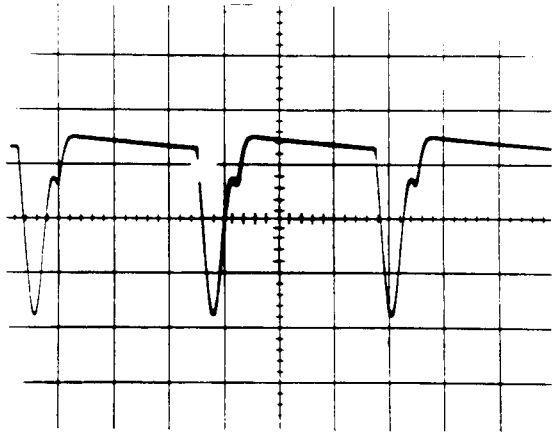
INCORRECT PHASING



18889-P10

ILLUSTRATION 66

OUTPUT



18890-P10

ILLUSTRATION 67

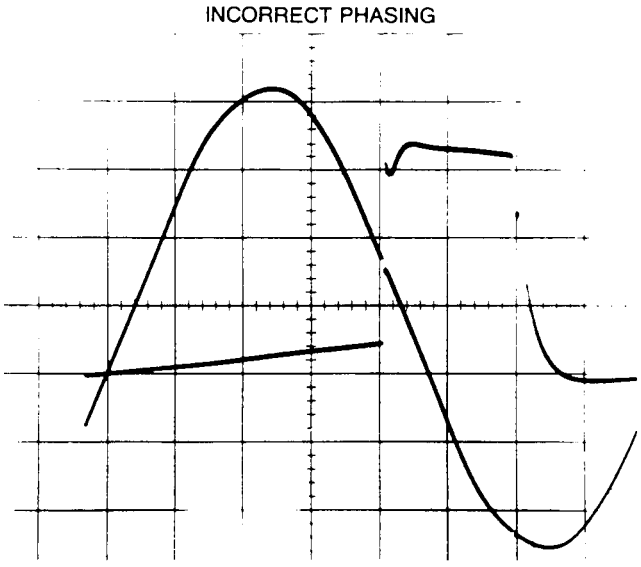


ILLUSTRATION 68 18891-P10

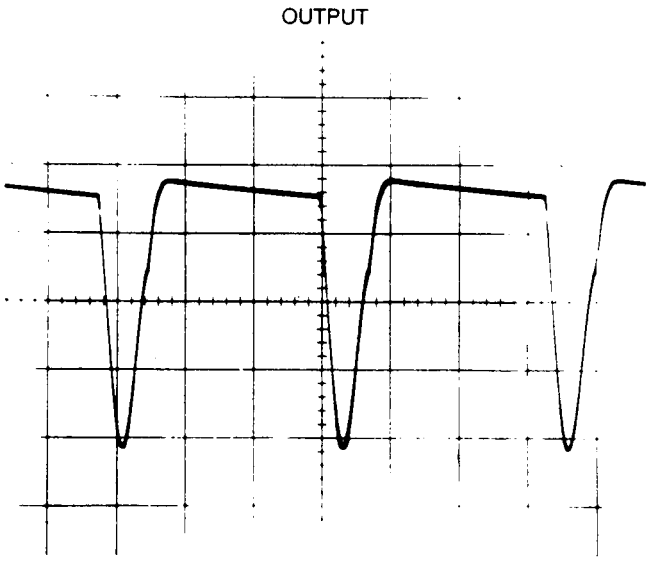


ILLUSTRATION 69 18892-P10

Illustration 65 shows the normal kVp output of a KXE-225 X-ray generator as observed with a HV Bleeder and scope when the Fluoricon pulse generator is adjusted correctly as shown in Illustration 64. Correct adjustment requires pulse width not less than 4 ms and phased to the center of the positive pulses of AC power input to the HV transformer primary. Also, it is necessary that the Fluoricon pulse height adjustment (given in Fluoricon installation directions) be correct. (Pulse height adjustments are not needed for Fluoricon II and pulse generator Models 11CP5B1 and 11CP5C1.) Driving the grid more than +200V positive causes enlarged focal spot and out of focus films. If the grid is not maintained more positive than -200V during the 4 ms pulse, the focal spot becomes smaller. At considerably more negative voltages the X-ray tube anode may be overloaded. It will be difficult to maintain mA and space charge compensation unless excessive filament voltages are used and the HV transformer may draw abnormal (high) currents.

Comparison of the 3 situations shown in Illustrations 64 to 69 is shown in Table 3.

There is a pulse phasing setting in between those shown in Illustrations 66 and 68 where the no-load kVp goes to 100 during the 4 ms pulses although the primary voltage is set for 80 kVp.

Illustration 67 shows abnormal kVp output of a KXE-225 X-ray generator as observed with a HV Bleeder and scope when the Fluoricon pulse generator was incorrectly adjusted by turning potentiometer R-26 fully CCW. Although HV transformer primary voltage is the same as for Illustration 65, the no-load kVp is 10 kVp higher due to incorrect pulse phasing. Such an abnormal condition can overvoltage the KXE-225 X-ray generator when it is operated near its 125-kVp rating. Also, note from the table that the relative R-output is only 70% of what it was for correct phasing.

Illustration 69 shows abnormal kVp output of a KXE-225 X-ray generator as observed with a HV Bleeder and scope when the Fluoricon pulse generator was incorrectly adjusted by turning potentiometer R-26 fully CW.

Although the HV transformer primary voltage is the same as for Illustration 65, the no-load kVp is 16-kVp higher due to incorrect pulse phasing. Such an abnormal condition can overvoltage the KXE-225 X-ray generator when it is operated near its 1 25-kVp rating. Also note from the table that the relative R-output is only 40% of what it was with correct phasing.

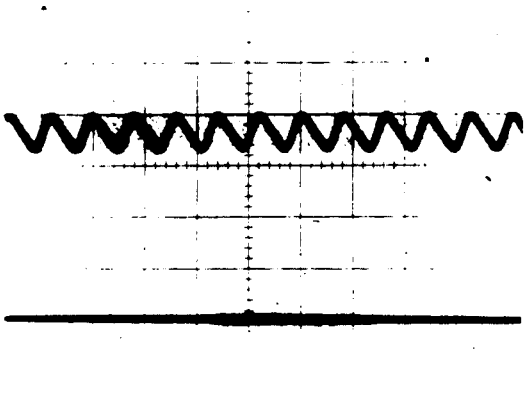
TABLE 3

Illustration Number	Load Primary Volts	Actual mA	Actual kVp	Primary Current (Amps)	R/Min
64 and 65	124	20.0	80	22.0	3.0
66 and 67	124	19.0	90	23.5	2.1
68 and 69	125	17.2	96	20.0	1.2

12-5 ADDITION OF PULSE SYSTEM CAPACITOR

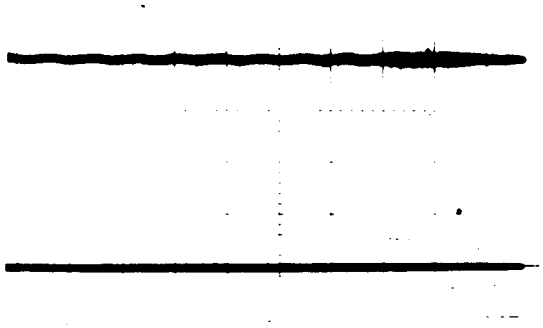
1. Normal Fluoroscopy

Scope: Tektronix 422
H: 10 ms/div
V: 2V/div x 10 probe x 1000 Bleeder
Trigger: DC, EXT
CH1: See HV Bleeder Direction for connections
CH2: See HV Bleeder Direction for connections



18893-P10

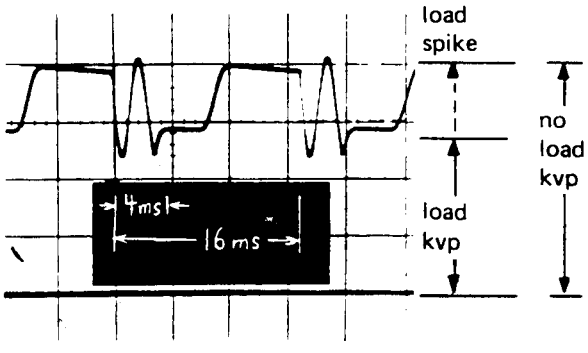
BEFORE CAPACITOR FILTER
80 kVp, 3 mA
ILLUSTRATION 70



18894-P10

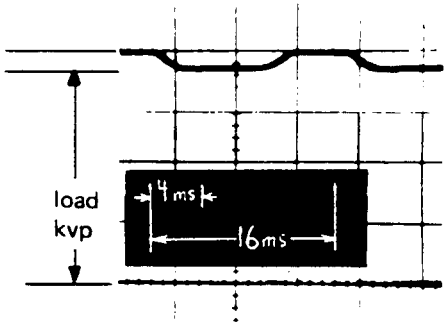
AFTER CAPACITOR FILTER
80 kVp, 3 mA
ILLUSTRATION 71

2. Pulsed Fluoroscopy, low mA



18895-P10

BEFORE CAPACITOR FILTER
ILLUSTRATION 72



18896-P10

AFTER CAPACITOR FILTER
ILLUSTRATION 73

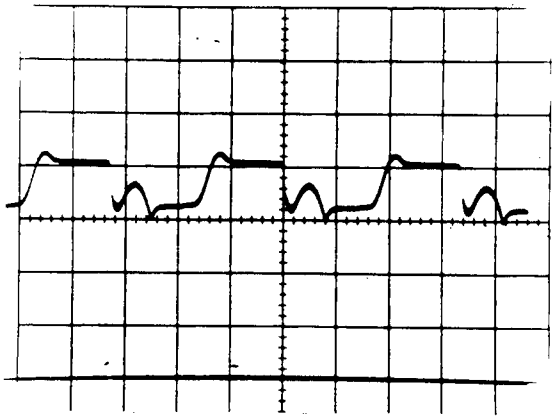
3. Pulsed Fluoroscopy, High mA

Scope Settings:

H: 5 ms/div

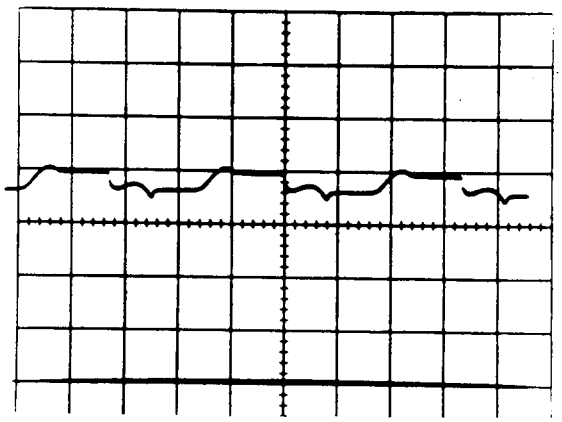
V: 2V/div x 10 for Probe x 1000 for Bleeder

Illustrations 74 and 75 show the effects of the capacitor at high mA (above 30) neglecting the expected change in kVp produced by additional loading.



18897-P10

BEFORE CAPACITOR FILTER
ILLUSTRATION 74



18898-P10

AFTER CAPACITOR FILTER
ILLUSTRATION 75

SECTION 13 — APPLICATIONS IN TROUBLESHOOTING

13-1 GENERAL

The High Voltage Bleeder and oscilloscope combination can be utilized for troubleshooting in addition to kVp calibration. The output of the X-ray unit observed with this apparatus will indicate whether the sync circuits are starting exposures properly, whether the timer is providing the correct exposure time intervals, and whether transients detrimental to the X-ray apparatus are occur-ring.

13-2 ELECTRONIC INTERVAL TIMER

For single phase X-ray units look for correct number of whole pulses. For longer exposures, check that the scope horizontal sweep is correctly calibrated, then observe that number of divisions covered by the trace times the ms/div selected on the scope equals the time interval selected on the X-ray control dial or push button.

For three phase X-ray units, check that the scope horizontal sweep is correctly calibrated, then observe that the number of divisions covered by the trace at 75% of the height of the waveform times the ms/div selected on the scope equals the time interval selected on the X-ray control push button. An example of how to read the time interval from the waveform is shown in Illustration 45.

13-3 FUNCTION OF MECHANICAL CONTACTOR IN HV TRANSFORMER PRIMARY (Older Units)

If the pull-in adjustment is not correct or if the contacts on the X-ray contactor are bad, the step in the rise of the first pulse will be out of place and that pulse will show excessive height or a spike at the top. Operation at maximum rated kVp under such conditions can stress the X-ray apparatus severely or cause failure of HV cable, X-ray tube or HV transformer.

If the drop out adjustment is not correct, the waveform will show a partial pulse at the end of the trace. This indicates breaking too early or late in a pulse accompanied by excessive arcing and burning of the contactor contacts.

13-4 FUNCTION OF SYNCHRONIZING AND PULSE POLARITY SELECTOR CIRCUITS (Older Units)

When an exposure with an odd number of pulses is to be made, the X-ray unit must start it on a pulse of opposite polarity to the last pulse of the preceding exposure. If this is not done, the HV transformer saturates and starting currents become excessive. If the first pulse of an exposure is abnormal, disconnect the HV transformer to X-ray control wires at the P1L and P2E terminals and transfer the scope to those terminals (connected through an isolation transformer). Check whether the exposures start on pulses of correct polarity. Note that this does not apply to MSI units in rapid film and photospot modes. Consult individual X-ray control service manuals.

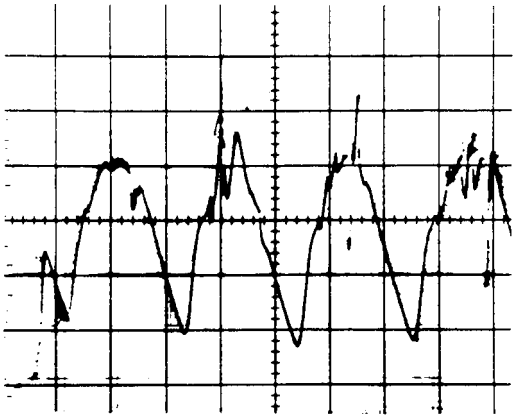
13-5 FLASH-OVER IN THE X-RAY TUBE

Severe transients and rapid oscillations will occur in the HV transformer secondary circuit when an X-ray tube flashes (arcs). One example of the waveform which will be displayed on the scope in such cases is shown in Illustration 76. Keep in mind that scope writing speed is a factor in observing transients. Therefore, the spikes or oscillations may not be visible if the scope intensity is set too low. They also may not be visible it the storage feature of the scope is used because writing speed in the storage mode is considerably less than in conventional use. Illustration 76 was made with the storage feature shut off. With storage on, the oscillations are not as clearly defined and may appear as a missing pulse in the train of pulses.

13-6 HIGH VOLTAGE BREAKDOWN

The oscillogram below shows the waveform obtained on a single phase X-ray unit when the X-ray tube is gassy. In this case the DXS-550 X-ray unit kicked off when exposures above 80 kVp, 100 mA were attempted.

EXP:100 mA, 80 kVp, 1/30 sec.
Scope settings same as for Illustrations 17 to 24 except H was 5 ms/div

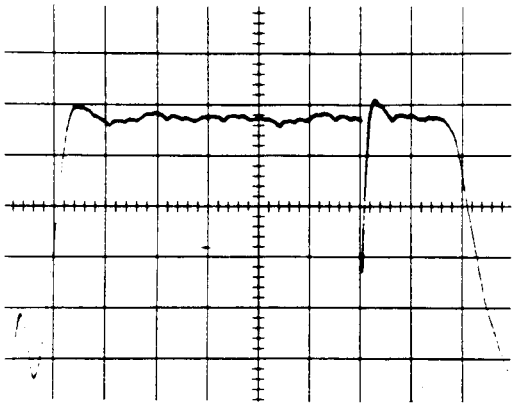


18899-P10

ILLUSTRATION 76

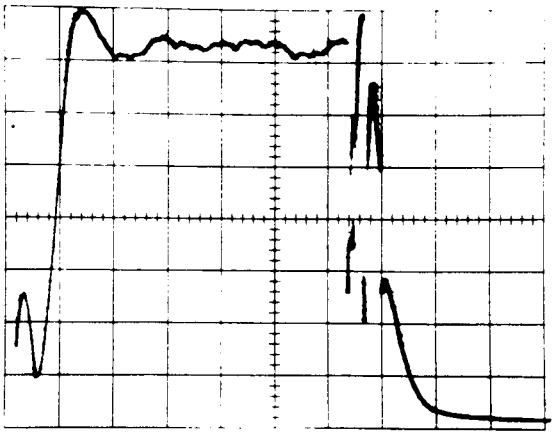
Illustrations 77 through 80 show breakdowns in a 3-phase DXR unit. Illustrations 77 and 78 show relatively mild tube arcing (sharp discontinuities near trailing edge of exposure). The exposure of Illustration 79 produced a drastic breakdown which resulted in a blown FRN-50 fuse followed by one single-phase pulse before termination. The arcing of Illustration 79 produced a "ringing", i.e., oscillation of the transformer winding with cable capacitance. This may produce higher-than-normal voltage which can deteriorate cable or transformer insulation.

Where arcing is mild enough to permit, attempt to condition the X-ray tube in accordance with Direction 13804 before replacing.



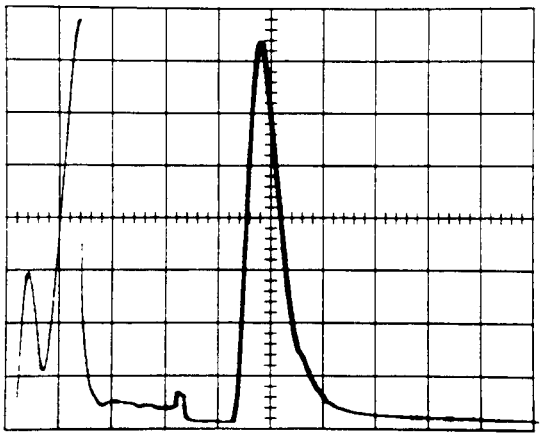
18900-P10

ILLUSTRATION 77



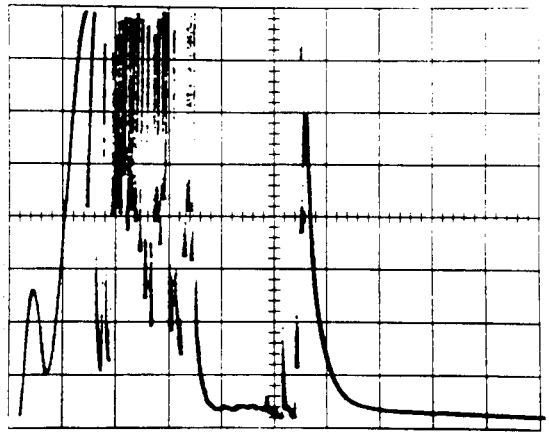
18901-P10

ILLUSTRATION 78



18902-P10

ILLUSTRATION 79



18903-P10

ILLUSTRATION 80

13-7 LOCATING DEFECTIVE HV COMPONENTS BY ELIMINATION

Cables, pulse transformer, pulse capacitors, etc., which are defective may be identified by systematically removing the components one at a time until the Bleeder shows HV breakdown no longer occurs. The last component removed is then rechecked as the likely faulty component. Usually the procedure is started at the tube unit, whose HV cables are removed from the tube unit and plugged into the HV Bleeder. If all is well, the tube unit is defective. If breakdown persists, remove the HV cables to which the Bleeder is connected, reconnecting it to the well from which the cables were just removed using known good cables. Continue to eliminate back to the HV transformer.

In using this procedure, the following precautions must be observed:

1. When tube unit is removed, filament relay contacts must be jumpered in order to obtain high voltage.

2. When operating without X-ray load, start with HV set at least 30 kVp below rating (example, start a 150 kVp system at 120 kVp), and increase kVp in 5 kVp steps until reaching 10 kVp below rating. Observe leading-edge-overshoot on scope, and at no time allow overshoot to exceed kVp rating. Overshoot will be higher than normal on an unloaded system.

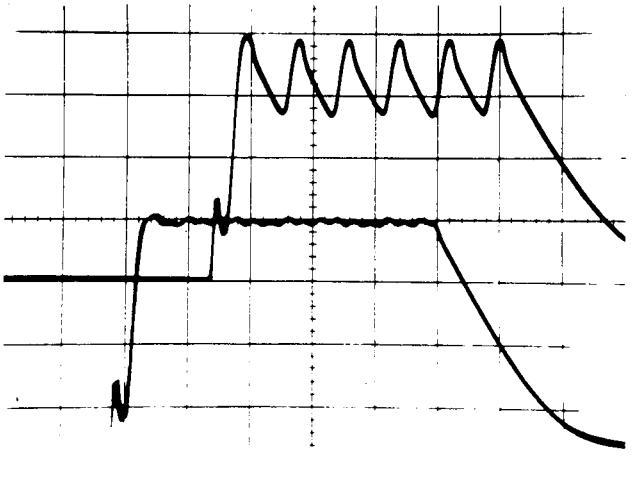
3. Always fill un used energized HV wells with oil before exposure. Failure to do so may result in corona or air breakdown which will give erroneous scope indication, and may cause damage.

4. HV breakdown will be seen as jagged spikes and abrupt discontinuities in the waveform. Since the system is unloaded, there may be an unusually long decay time as the cables discharge.

WARNING: WHEN WORKING WITH AN UNLOADED HV SYSTEM, BE VERY CAREFUL TO DISCHARGE SYSTEM CAPACITY WITH A GROUND ROD, ETC., BEFORE CHANGING HV CONNECTIONS.

13-8 SINGLE PHASE OPERATION OF THREE PHASE X-RAY UNITS

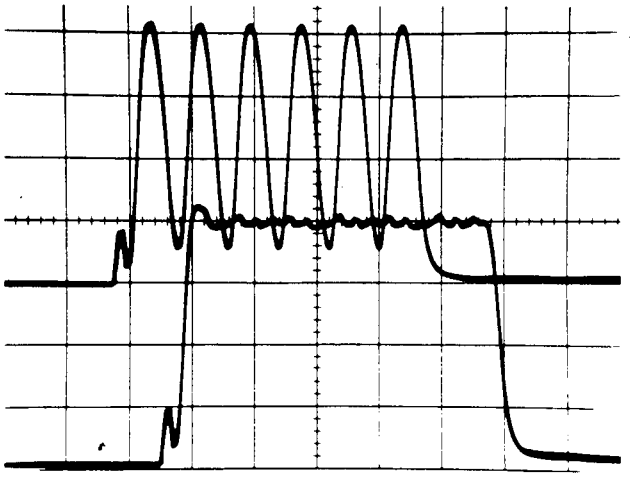
If some malfunction causes a three phase X-ray unit to operate single phase, the waveform will change as shown in Illustrations 81 and 82. The scope and Bleeder connections and settings for these were the same as for Illustration 40 to Illustration 44.



18904-P10

ILLUSTRATION 81

Exp: 25S mA, 80 kVp, 0.05 sec.
Upper Trace - Normal 3-phase operation
Lower Trace - Not normal 1-phase operation (one phase open)



18905-P10

ILLUSTRATION 82

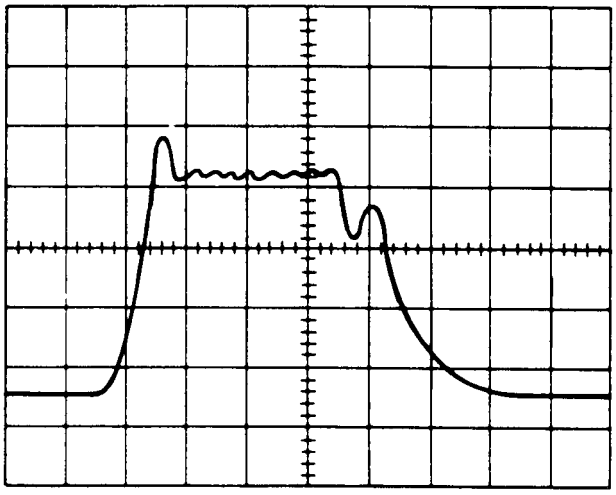
Exp: 500L mA, 80 kVp, 0.05 sec.
Upper Trace - Normal 3-phase operation
Lower Trace - Not normal 1-phase operation (one phase open)

13-9 OTHER DEFECTS

Illustration 83 is included as an interesting malfunction. It was obtained from an MST 1050. The only abnormality observable without test equipment was the sound of the safety contactor dropping out upon exposure termination. Exposure time corresponded to the dial setting in every case. The problem was traced to a defective transistor, Q35, on the 58 panel.

13-10 OPERATING PRECAUTIONS

Where the scope probes are clipped to the two-conductor shielded cable, do not allow the probes to rest on the floor because some hospital floors are conductive and the scope reading may be affected.



SIMULATED WAVEFORM
ILLUSTRATION 83